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The American Association for the Advancement of Science:
Mathematics and Science: PROFESSOR C. N. MOORE 27

Agricultural Planning as an Aspect of State and National Planning: PROFESSOR A. R. MANN 32

Obituary:
Otto Folin: DR. PHILIP A. SHAFFER. *Tribute to Professor Folin:* DR. HENRY A. CHRISTIAN 35

Scientific Events:
The Construction of a Barrage across the Tigris; The Drought and Autumn Rains; The Presidency of the American Chemical Society 38

Scientific Notes and News 41

Discussion:
The Nature of Enzymes: JEROME ALEXANDER. *The Density of Water in Relation to Its Thermal History:* DR. MALCOLM DOLE and B. Z. WIENER. *Ploughing under the Science Crop:* PROFESSOR L. MAGRUDER PASSANO 44

Quotations:
Science in the News 46

Scientific Books:
The Architecture of the Universe: DR. F. R. MOULTON. *A Study of Superstition:* DR. JOSEPH JASTROW 47

Scientific Apparatus and Laboratory Methods:
The Gear Pump and Hose as a Collector of Water Samples for Gas Analysis: PROFESSOR R. P. COWLES and DR. CHARLES BRAMBEL. *Methionine as an Impurity in Natural Leucine Preparations:* DR. J. HOWARD MUELLER 48

Special Articles:
Electrical Potentials from the Intact Human Brain: DR. H. H. JASPER and DR. L. CARMICHAEL. *The Long Wave-Length Limit of Photolethal Action in the Ultra-Violet:* DR. A. C. GIESE and PROFESSOR P. A. LEIGHTON 51

Science News 8

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MATHEMATICS AND SCIENCE[1]

By Professor CHARLES N. MOORE

UNIVERSITY OF CINCINNATI

THE retiring chairmen of Section A have frequently devoted their addresses to some large phase of mathematical theory connected with their own scientific work. Since their audience and doubtless the bulk of their readers constitute a group whose primary scientific interest is in the field of mathematics, this has been an appropriate procedure. I have chosen to give a somewhat different type of address, for which I think there is also adequate justification. The American Association for the Advancement of Science is an organization that stands for cooperative enterprise among the various scientific groups. I have always felt that an emphasis on the connection between mathematical progress and general scientific progress should constitute one of the most important activities of Section A as a separate entity. For that reason I have elected to speak on the relationship between mathematics and science.

The origins of mathematics and science are lost in the mists of antiquity. As far back, however, as it has been possible for historians in these fields to trace the records, it has been found that science in general and mathematics in particular have undergone a simultaneous and parallel development. A little reflection will convince any thoughtful person why this must have been the case. It is quite apparent that astronomy, one of the earliest fields to attain what may properly be called a scientific form, could not have been seriously advanced without the assistance of a well-developed mathematical apparatus. Even the most descriptive form of scientific development in other fields could hardly have had its inception without making use of counting and calculation. It is well to recall that these elementary phases of mathematics, now become a matter of pure routine, were,

[1] Address of the vice-president and chairman of the Section of Mathematics, American Association for the Advancement of Science, Pittsburgh, 1934.

in the infancy of the subject, mathematical discoveries of a very high order.

The usefulness of mathematics in other fields has sometimes led superficial observers to urge that mathematicians as a class should devote their time exclusively to problems which are of immediate concern to other scientists. Without touching on the question as to whether or not it is beneath the dignity of mathematics to play the rôle of a glorified valet to the other sciences, the whole history of mathematics and science shows that from a purely utilitarian standpoint this course would be eminently short-sighted.

The notion of number undoubtedly had its beginning in man's sense perceptions; the conception of a number as a purely abstract idea, however, was a great triumph of creative imagination and paved the way for much of the vast development of mathematical theory. The operation of counting was closely associated with practical needs, if in fact it did not originate from them. All the fundamental operations of elementary arithmetic can be reduced to a question of counting, if we restrict ourselves to the positive integers in connection with which they arose. When, however, these operations were examined as independent processes, the investigations eventually resulted in a very extensive elaboration of the number class. We find illustrated here one of the most important procedures that lead to mathematical growth; namely, a synthetic process followed by an analytic process. We synthesize a large number of related ideas into a more general idea for the purpose of economy of thought and economy of procedure. Then we analyze the more general idea for all its ultimate implications and, lo and behold, a host of new ideas is found to be contained in our generalization. It has very much the appearance of rabbits tumbling out of a magician's hat, but here there is no hocus-pocus. Creative imagination and strenuous intellectual labor have succeeded in enriching our stock of mathematical ideas.

The process of growth to which we have referred is again illustrated in striking fashion in the passage from arithmetic to algebra. The first synthesis of various arithmetical operations into an algebraic formula goes back into the prehistoric period of mathematics, for we find such a synthesis appearing in the earliest known mathematical writings. It could not have been said to have been properly completed, however, until our modern algebraic notation took form. From that time on the analysis of algebraic operations, which had already been carried forward to a considerable degree, grew apace. We have the so-called imaginary and complex numbers appearing first as purely formal solutions of certain types of algebraic equations, then being recognized as independent entities and given a concrete geometric representation, finally being assimilated into a complete number system and forming the basis of a beautiful mathematical theory with wide ramifications, namely, the theory of functions of a complex variable. It is well known that for some time past this theory has found extensive applications in many branches of mathematical physics. In the newly created spinor analysis complex numbers seem to enter in some essential manner, rather than merely as a tool, as Veblen has recently pointed out.[2] Does any one believe that mathematicians would have arrived at the notion of complex numbers, to say nothing of extensive theories concerning them, if they had confined themselves to problems having immediate practical applications?

The failure of the methods of solution which had been effective for quadratic, cubic and biquadratic equations to yield similar success in the case of quintic equations led finally to Abel's brilliant discovery of the impossibility of such success. A systematic analysis of algebraic equations of higher degree at the hands of Galois led to the notion of groups of transformations. Thus we see emerging the basic ideas which are at the foundation of the theory of groups. In the present century we find far-reaching applications of this theory in the field of mathematical physics by Weyl, Wigner and others.[3] The consideration of sets of linear algebraic equations led first to the notion of a matrix and then by the natural laws of mathematical growth to a comprehensive theory of matrices, including infinite matrices. Quite recently this general matrix theory has been of important service to Heisenberg and other mathematical physicists. It is difficult to see how either group theory or matrix theory could have been evolved by mathematicians who were concentrating their attention exclusively on problems with an immediate physical significance. The mathematicians have created these theories in what seems to have been the only possible way, namely, by developing the science of mathematics along its own inherent lines of growth.

The postulates of Euclid represent the ultimate step in the Greek synthesis of geometric ideas and relationships. On these postulates as a basis a comprehensive geometric theory was elaborated by purely logical processes. An important part of this theory dealt with the curves known as conic sections. Thus an extensive knowledge of the geometric properties of these curves was attained by mathematicians who

[2] Oswald Veblen, SCIENCE, 80: 415–419, 1934.

[3] Herman Weyl, "Gruppentheorie und Quantenmechanik," Leipzig, 1928, 1931 (English translation of 2nd edition by H. P. Robertson). Eugen Wigner, "Gruppentheorie und ihre Anwendung auf die Quantenmechanik der Atomspektren," Braunschweig, 1931.

were advancing their subject in the manner its own nature demanded and not merely for the applications. Centuries later the astronomer Kepler found that the theory of conic sections was precisely what he needed to develop the laws of planetary motion.

The substantial completion of the synthetic operation involved in developing an effective algebraic notation paved the way for the next great step in the development of mathematics. This was the synthesis of algebra and geometry as then known into the analytic geometry of Descartes. This noteworthy advance is usually regarded as the beginning of modern mathematics, and certainly the growth of mathematical theory was enormously stimulated by it. Although this discovery is something less than three hundred years old, it has now so penetrated the thinking of the whole literate group that the newspapers of the day do not hesitate to use graphical representation.

The basic ideas of the differential calculus and the integral calculus developed in somewhat closer touch with the applications than in the case of many other mathematical theories. However, the recognition by Newton and Leibniz of the close relationship between the two methods of investigation and the binding link between their fundamental concepts ranks among the most brilliant mathematical syntheses due to individual effort. This synthesis having been made, the subsequent analysis resulted in forging the most powerful method of mathematical investigation which had yet been known. The calculus thus established enabled Newton to substantiate his theory of gravitation by deducing Kepler's laws from it, and his successors during the next two centuries to develop a comprehensive and majestic theory of the motions of the heavenly bodies.

In connection with the postulates of Euclid we find arising a new type of analytic procedure, namely, the analysis of the logical foundations of a subject to see whether or not they can be improved. The long struggle to prove the parallel postulate from the other postulates finally led to the construction by Bolyai and Lobaschevsky of logically consistent geometries in which the parallel postulate of Euclid was replaced by an essentially different one. Thus we have the origin of the non-Euclidean geometries. Until quite recently the majority of scientists in other fields, if they knew anything about the non-Euclidean geometries at all, must have felt that they should be ranked among mathematical recreations rather than as a serious scientific study capable of application to the physical sciences. The general relativity of Einstein shows that this is far from being the case, and that without the theories which grew out of the logical qualms of the mathematicians it would not have been possible to replace Newton's theory of gravitation by a more general one. For this task there was needed not only the geometric ideas involved in the non-Euclidean geometries, but also the related analytical development known as the absolute calculus.

The importance of trigonometric series seems to have been first indicated in connection with the applications of mathematics to physics, and it was in connection with such applications that Fourier laid the basis for a comprehensive study of them. After Fourier, however, these series were studied by various eminent mathematicians from the point of view of their own mathematical content, aside from their utility in the applications. It has been pointed out in a previous address[4] by a retiring chairman of Section A how this study led to the development of many of the important new notions of nineteenth century mathematics, such as the Riemann integral, the point-set theory of Cantor, etc. In fact, the whole present form of the theory of functions of a real variable has been largely conditioned by ideas which arose in connection with the detailed study of trigonometric series. This is one striking instance of many cases in which mathematics owes a debt to other sciences for suggesting problems which lead to noteworthy advances. I have insisted before that it would be a grave mistake for mathematicians to devote themselves exclusively to problems which arise in other sciences. It would also be a grave mistake to ignore such problems. For in addition to aiding in the development of the other sciences, the complete analysis of the problem from a mathematician's view-point often leads to important new ideas. However remote these ideas seem to be from the original problem, they frequently find application in the same or related sciences. It was by means of trigonometric series that Weierstrass and others succeeded in giving examples of continuous functions which nowhere possess a derivative. Fourier and his contemporaries, to say nothing of mathematical physicists of later generations, would have undoubtedly regarded such functions as excellent examples of the manner in which mathematicians sometimes waste their time. Yet an eminent physical chemist of the day, Jean Perrin, has pointed out that careful studies of the Brownian movement show that the trajectories of the particles suggest nothing so much as continuous functions without a derivative. In Chapter IV of his book "Les Atomes" we find the statement:

> The entanglements of the trajectory are so numerous and so rapid that it is impossible to follow them and the trajectory noted is infinitely simpler and shorter than the real trajectory. Likewise, the mean apparent velocity of a particle during a given time varies wildly in magnitude and direction without tending to a limit when the

[4] E. B. Van Vleck, SCIENCE, 29: 113–124, 1914.

time of the observer decreases, as we see in a simple fashion by noting the positions of a particle in the camera lucida, first from minute to minute, and then every five seconds, or better still by photographing them each twentieth of a second, as has been done by Victor Henri, Comandon and de Broglie, in order to cinematograph the movement. One can no longer fix a tangent, even in approximate fashion, at any point of the trajectory, and we have a case where it is truly natural to think of those continuous functions without derivatives, which the mathematicians have devised and which one would regard erroneously as mere mathematical curiosities, since Nature suggests them as well as functions with a derivative.

In the preface to the same book Perrin takes occasion to justify at some length, and in admirable fashion, the more recondite labors of the mathematicians. Since the statements of a physical chemist can hardly be qualified as mathematical propaganda, I think it will be of interest to repeat some of his remarks.

We all know how, before a rigorous definition is given, we point out to beginners that they already possess the notion of continuity. We trace before them a beautifully smooth curve, and we remark on placing a ruler against the contour: "You see that at each point there exists a tangent." Or again, to communicate the still more abstract idea of the true velocity of a moving body at a point of its trajectory, we say: "You surely perceive, do you not, that the mean velocity between two neighboring points of this trajectory becomes approximately constant when the points approach each other indefinitely?" And many minds, indeed, remembering that for certain familiar movements it appears to be so, do not see that the situation involves great difficulties.

The mathematicians, however, have well understood the defect in rigor of these so-called geometric considerations, and how childish it is, for example, to attempt to demonstrate, by tracing a curve, that every continuous function possesses a derivative. Functions with a derivative are the simplest and the easiest to deal with, but they are nevertheless an exceptional case; or, if we prefer geometric language, curves which have no tangents are the rule, and the very regular curves, such as the circle, are very interesting but very special cases.

At first glance such restrictions seem to be only an intellectual exercise, ingenious without doubt, but definitely artificial and sterile, involving the pushing to a mania of the desire for complete rigor. And, most frequently, those to whom one speaks of curves without tangents or functions without derivatives, begin by thinking that Nature does not present such complications nor even suggest the idea of them. The contrary is nevertheless true, and the logic of the mathematicians has kept them nearer to reality than the supposedly more practical representations of the physicists.

It is well to note here that many of the leading workers of the day in other scientific fields where mathematics is applied realize quite clearly that mathematics has served them best by following its own lines of development. In a recent article by Langevin[5] we find the following statement:

It is nevertheless just and necessary to emphasize here the remarkable fact that among the abstract constructions realized by the mathematicians, while taking for an exclusive guide their need for logical perfection and increasing generality, none seems to remain useless to the physicist. By a singular harmony, the needs of the mind, desirous of constructing an adequate representation of reality, seem to have been foreseen and provided for by the logical analysis and the abstract esthetics of the mathematician.

We also find in a recent paper by Dirac[6] the following remarks:

The steady progress of physics requires for its theoretical formulation a mathematics that gets continually more advanced. This is only natural and to be expected. What, however, was not expected by the scientific workers of the last century was the particular form that the line of advancement would take, namely, it was expected that the mathematics would get more and more and more complicated, but would rest on a permanent basis of axioms and definitions, while actually the modern physical developments have required a mathematics that continually shifts its foundations and gets more abstract. Non-Euclidean geometry and non-commutative algebra, which were at one time considered to be purely fictions of the mind and pastimes for logical thinkers, have now been found to be very necessary for the description of general facts of the physical world.

Finally, in a recent presidential address before the British Association for the Advancement of Science, we find the following statement by Jeans:[7]

Our knowledge of the external world must always consist of numbers, and our picture of the universe—the synthesis of our knowledge—must necessarily be mathematical in form. All the concrete details of the picture, the ether and atoms and electrons, are mere clothing that we ourselves drape over our mathematical symbols—they do not belong to Nature, but to the parables by which we try to make Nature comprehensible. It was, I think, Kronecker who said that in arithmetic God made the integers and man made the rest, in the same spirit, we may add that in physics God made the mathematics and man made the rest.

After such eloquent testimony in behalf of my thesis from distinguished workers in other scientific fields, I can only make suitable acknowledgement by repeating

[5] Paul Langevin, "L'orientation actuelle de la Physique," in "L'orientation actuelle des Sciences," Paris, 1930.

[6] P. A. M. Dirac, *Proc. Royal Society, London*, 133A: 60–72, 1931.

[7] J. H. Jeans, *Nature*, 134: 355–365, 1934.

my previous injunction to workers in pure mathematics that they should keep in touch with the developments in other sciences. It will always be eminently desirable that at least some of the mathematicians should be on the alert for new problems which arise from sources outside of mathematics. Such problems have provided a powerful stimulus of growth in the past and will undoubtedly continue to do so.

At the present stage of development of both mathematics and science, the relationships between them and their mutual services are best illustrated in the fields previously mentioned, namely astronomy, physics and physical chemistry. There exists no branch of science, however, in which some mathematical procedure is not found essential. Moreover, the natural evolution of all scientific theory is in the direction of increasing use of quantitative methods. It seems inevitable that the applications of mathematics in the more descriptive sciences should be enormously extended in the future. Many indications of the processes leading to such extension can be found in recent scientific advances in various fields. For example, the application of statistical methods in the biological and sociological fields is steadily increasing. In view of the fact that in the recent past no special mathematical preparation was regarded as important for workers in these fields, such an increase is noteworthy. We also find cropping up in these same sciences quite unexpected and rather startling instances of the possibilities of mathematical application. An example of this is found in the curve of healing of a wound developed by Carrel and du Noüy[8] during the late war.

In a recent article by Lapicque[9] we have clear indication as to the manner in which the relatively new science of physiology is evolving into a form where mathematical applications will be not only possible but essential. His remarks are as follows:

> Formerly, not very far back in the history of humanity, let us say a century ago, almost everything was unknown concerning the physiology in the labyrinth of a living body. Magendie said: "I wander around there like a rag picker, and at each step I find something interesting to put in my basket." This maxim horrified my teacher, Dastre, who was wont to say: "When one doesn't know what he is looking for, he doesn't know what he finds." For him the ideal of physiological research would have been to conceive in the quiet of one's study a theory explaining such and such a phenomenon, known but not understood (physiology is full of phenomena of this character), then to find, still by meditation, the experiment capable by a yes or a no, of proving or disproving the theory. One would come then some morning to the laboratory, and that very evening the matter would be decided.
>
> These two tendencies, each in its amusingly exaggerated form, seem to me to serve the purpose of characterizing the temperament of naturalists and that of physicists. In proportion as physiology develops, the discoveries for rag-pickers become more rare, and the possibility of working as Dastre dreamed is approaching. The progress of the physical sciences is one of the essential conditions of this development. Physical chemistry, notably the new fashion of interpreting the statics and dynamics of solutions, the rôle of membranes, the infinite variability of colloids, has opened for us new horizons and permits us to understand many phenomena which the older chemistry did not explain. To-day, we tend more and more to explain the vital processes in terms of physical chemistry; we have before us an enormous domain to exploit in this manner.

Certainly if the physiologists are going to explain vital phenomena in terms of physical chemistry, they will need to make extensive use of mathematical methods. Colloids, for example, which are mentioned above, are referred to by Perrin as one of the aspects of nature which suggest continuous functions without a derivative. It seems quite reasonable to suppose that many of the future applications of mathematics in such fields as the biological and sociological sciences must wait on further development of mathematical theory as well as further development of the sciences in question. We should remember that the absolute calculus only reached definitive form some fifteen years before the publication of the first paper on general relativity. The present extensive development of the mathematical theory of atomic structure depends in part on advances in pure mathematics which are of quite recent origin. The inner details of biological phenomena are undoubtedly more complex than atomic structure, and the extensive application of mathematics to biology will in all probability involve mathematical theories as yet unborn.

On the other hand, we have in existence beautiful and extensive theories of pure mathematics which have as yet found no application in other scientific fields. One outstanding example of this sort is the theory concerning the distribution of prime numbers among the other integers. Since all integers can be expressed as the products of primes, and since all the other numbers of mathematics rest on integers as a basis, there is ample justification for the statement of Landau that the prime numbers should be regarded as the "building stones" of mathematics. Recent developments in physical theory suggest that the assumption of a discrete structure for the material world, rather than a continuous structure, is more in

[8] P. Lecomte du Noüy, "Recherches expérimentales et applications des méthodes de mesure et de calcul a un phénomène biologique: la cicatrisation," Paris thesis, 1917.

[9] L. Lapicque, "L'orientation actuelle de la Physiologie," in "L'orientation actuelle des sciences," Paris, 1930.

accordance with physical reality. Perhaps prime number theory, like the conic sections of the Greeks, is waiting for some future Kepler to derive from it important theories concerning the physical universe.

The point that I would like to insist on in closing is the essential unity of all that can be designated as science. One outstanding purpose lies at the basis of all scientific endeavor, as the etymological origin of the word science indicates. We wish to increase our knowledge, both of ourselves and of the world about us. In carrying out this purpose each individual works best along lines dictated by his own tastes and inherent capacities. Some of us are for this reason mathematicians, and more particularly mathematicians working in certain special fields. If the theories we develop had no bearing at all on other scientific work, they would still have a value as exhibiting the capacities of the human mind. But the interrelations of the various scientific fields adds much to the solidarity of scientific interests. We should therefore rejoice that the relationships between mathematics and the other sciences are of such great service in the general development of scientific thought. It may not make our work any more interesting to ourselves, but it adds much to its broad human interest.

AGRICULTURAL PLANNING AS AN ASPECT OF STATE AND NATIONAL PLANNING[1]

By Professor A. R. MANN
PROVOST OF CORNELL UNIVERSITY

AGRICULTURAL planning is proceeding in this country in two distinct but not unrelated forms. These two forms are perhaps best represented by the production control program of the Agricultural Adjustment Administration, on the one hand, and by the work of the Land Policy Division of the Agricultural Adjustment Administration and of the National Resources Board in conjunction with state planning boards, on the other hand.

The first of these types of planning, economic planning, tends towards a "planned agricultural economy" as that term is currently applied. It seeks to determine the quantity of certain agricultural products which the markets and consumption on the farm will absorb under existing and anticipated conditions, and the optimum carry-over in addition thereto, and to apply inducements, chiefly but not wholly financial, to accomplish such production. Before the inducements can be applied there must be the most thoroughgoing determination of the size of the agricultural plant most likely to yield the desired production under existing conditions without yielding disturbing surpluses. From production control as an immediate instrument this type of planning reaches out toward permanent adjustments in production, commerce and consumption of farm products such as will reestablish a normally balanced and compensating agricultural economy. This form of agricultural planning will receive somewhat extended treatment on the program of this meeting.

The second form of agricultural planning, and the one which is an integral part of state and national planning as contemplated in the title of this paper, is an aspect of the effort to plan the highest economic and social utilization of the natural resources of the nation in the interest of present and future generations. Its essential character is revealed in the declared purpose of the National Resources Board to prepare a program on all "aspects of the problem of development and use of land, water and other national resources in their physical, social, governmental and economic aspects." As the National Resources Board and its predecessor, the National Planning Board, is responsible for the present nation-wide movement for state planning, the work of the state planning boards is designed to accomplish similar purposes with respect to the natural resources within the several states. In the pursuit of these purposes the interests of agriculture are served in highly significant ways. Agricultural planning, in respect of some of its more fundamental features, emerges from the work of the national and the state planning boards.

While the two types of planning proceed from basically different intentions, they inevitably meet at a number of points.

BASIC SOCIAL TRENDS

The requirements of the nation for land and its products, for transportation routes and services, electric power lines, water supplies, stream control and many other utilities and services are affected by certain social trends which require evaluation. The first essential in the making of any plans for the future development of a state or of any other area is an understanding of basic conditions and trends. The

[1] Address of the retiring vice-president and chairman of Section O, American Association for the Advancement of Science, Pittsburgh, 1934.

facts must be assembled to establish the past trends and migrations and the present tendencies in agriculture, in industry, in commerce and in population distribution and concentration. Has agriculture been expanding into or receding from any areas under study? If so, why? If the character of farming is changing, what is causing the change and what is its significance for the future development of the area? What changes in location, size and character of mechanical industries have been taking place, why, and of what significance are the changes? What is the effect of these changes on migrations to or from the farms and on the demand for farm products? To what extent and in what industries and localities is decentralization of industry taking place or reasonably to be anticipated, and what adjustments in agriculture or the use of land, the development of highways and power lines, and the like, does such relocation of industry require?

What has been, and is, the trend in the size, the composition and the location of the population? What shifts are taking place in the proportion of the population engaged in the principal occupation groups, as in farming, mining, manufacturing, commerce, the professions, etc., and what bearing have these shifts on the future agricultural development of the state and the nation? Planners can not omit the implications of the slowing down of population growth and the changes in the age distributions within the population on the requirements either in physical development or in the creation and location of social institutions and utilities.

In many parts of the country the suburban trend has reached such proportions that it requires recognition in state and local planning. Consideration must be given to the increase in the number of rural non-farm homes and of small part-time farms within the environment of cities out to distances of perhaps thirty miles, and to the effect of good roads and motor vehicles on the movement from the more congested centers to suburban towns and villages. Studies have revealed some very striking facts concerning this movement and its significance for the future development both of the central cities and of the suburban towns and neighboring villages, as well as for the countryside. Questions also arise as to how the process of rapid suburbanization in certain areas, especially those outside the limits of incorporated cities and towns, can be regulated so as to avoid present evils.

In some states the problem of stranded populations must be dealt with. The first step is to locate the cities, villages and rural areas which have a large permanently unemployed population. Then the task is to determine whether industries, and what industries, can be located in such areas, and whether the stranded populations can be assisted by subsistence homesteads, small farm or allotment projects or other specific means.

As all expenditures and procedures for state and national development should be related to the actual and the potential needs of the people, all other elements in planning must be undergirt with the pertinent social or population facts.

Rural Land-Use Planning

The largest contribution to agricultural planning arising from the current national and state planning activities will apparently lie in the determination of the most socially desirable uses of the rural lands of the nation and how those uses may be effectuated. As a basis for such determination there must be available knowledge of present uses, the requirements of the nation for agricultural and forest lands, the nature of the soil resources, the factors which may affect the size of the necessary agricultural plant—especially the implications of any change in the foreign market for agricultural products and the increasing mechanization of farming—and other facts essential to dependable judgments concerning the uses of the nation's non-urban land resources.

In approaching a better planned use of the rural lands, the planning agencies are facilitating a broad classification of the lands into their most appropriate uses, whether for agriculture, forests, fish and game refuges, parks or other uses. Both the physical and the economic classification of lands are essential. For these purposes the studies involve, together with all pertinent economic data, the mapping and careful consideration of soil fertility, topography, length of growing season, rainfall, present intensity of use, school population and facilities, accessibility and other matters. A predominant purpose is to map the problem areas, the areas clearly submarginal for agriculture, and similarly to map the various categories from the marginal to superior farming areas, as a guide to the location of improved roads, electric power lines, recreational facilities, forests, wild life areas and other social utilities.

In many states, as a result of forest removal, loss of soil fertility, erosion, shift of population, changes in farm practises, especially the growth in machine farming, and other changes, great areas have gone out of cultivation, or nearly so, and have become problem areas. Much of this land is submarginal for agriculture. It must be located, mapped and described, and its possible alternative uses determined. While the chief alternative uses may be grazing, tree growth, water conservation, fish and game preserves, recrea-

tion and scenic or scientific reservations, there are many minor alternatives.

With the question of determining the alternative uses of submarginal areas goes the determination of how such lands should be owned or administered; by what legislative or other processes the desired developments may be inspired under private ownership; what areas should be purchased by the national, state or lesser governmental units for public reforestation, wild life preserves, water control, checking erosion, recreation or other desirable public enterprises.

Planning calls for careful determination not only of the uses to which the various types of land are best suited but also the requirements of the population for different categories of farm land, for forest products, water conservation, recreation areas, especially fishing and hunting areas, parks and camp grounds, wild life preserves and any other economic or social requirements which the non-urban lands may serve. The practicability of combined or multiple uses of land to serve these varied purposes requires determination.

Special problems of many sorts arise, such as those concerned with the possible development of extensive pasture areas on some of the hill lands in the east and the control and utilization of the range lands in the west; problems of the readjustment of size of holdings and types of farming, where maladjustments in these respects are evident; and problems arising from the menace of the soil and wind erosion, the former of which, at least, is taking heavy toll in all parts of the nation.

Closely related to these problems are those which deal with the changes in local governmental organization, in public services and utilities, in state aid to schools, and in road construction that are desirable in view of the probable future uses of these lands. Should the submarginal lands be zoned against future farm settlement? To what extent can the present population of these non-agricultural areas be absorbed in the activities, such as reforestation, recreation, game preserves and the like, which will take the place of such farming as is now practised? What procedures can be adopted to induce some of these submarginal farm families to settle on the more productive farm lands? These and kindred social questions obviously confront the planning agencies.

The Transportation Systems

In the field of transportation the facts must be assembled for all existent or prospective types of transportation, rail, water, highway and air transport. The mapping of all existing facilities, differentiated as to character, and the trends and the intensity of use are first steps. The questions of truck routes, farm-to-market roads, the place of the improved highway in a complete transportation system, the extent to which the public highway should supplement or supplant the railroad, the development of the highway and its borders to increase highway efficiency and to create or preserve beauty of the countryside, are some of the questions which enter. The relation of the development of transportation facilities to prospective land use is obviously very important if costly errors are to be avoided. So also are the relations to the trends or migrations in population, in industry and in commerce.

The Water Resources

The water problems are always important and in some areas are paramount. There is the question of securing and protecting adequate supplies of water for the large metropolitan areas, a matter of grave concern in the more densely populated sections of the country; of adequate supplies for the smaller centers for commercial and domestic use; the overcoming of serious stream pollution, which is a burning question in many places. There is the problem of flood control and its relation to soil erosion, afforestation, land use, swamp drainage and water storage and conservation. There is the problem of declining reservoirs of ground water and the control and protection of water for irrigation purposes. Attention must be given to the regulation of developments along streams and beside the public waters.

Power Production and Distribution and Industrial Location

In any study and mapping of the water resources of a state the question of power production is likely to gain prominence. This requires mapping and measuring both the developed and the undeveloped water power resources within the state, and determining what is involved in developing potential but now unused resources. Power production and distribution bear directly on the location of industries, existing and potential. Mapping the existing high tension distribution lines throws light on what the future problems of power distribution and utilization are. In the industrial states, a vital question is the relation of electric power distribution to the decentralization of industry. There are questions of major social significance bound up with the question of industrial location. In probably all the states the requirements for farm electrification should have clear recognition in planning; the relation of prospective land use to the extension of rural electric power lines scarcely requires discussion. In a number of states consideration must also be given to locations favorable to the production of electric power by steam.

PUBLIC WORKS PROJECTS

In state and national planning much emphasis has been given to public works which might relieve unemployment. This is an immediate phase, and it is also a major concern of long-term planning. As all manner of public works are appropriate for consideration, many items which directly concern farming and country life have place: the requirements of the population in the matter of highways, including farm-to-market roads, bridges, canals, parks, forests, fishing and hunting preserves, irrigation and drainage works, stream and flood control and water conservation are examples. There is involved consideration not only of what is required, but where and how it should be provided, its relation to all other pertinent state developments, and an effort to indicate the relative urgency of the many proposed public works.

MISCELLANEOUS ITEMS AFFECTING THE RURAL POPULATION

While state and national planning, having as its central objective the conservation and wisest utilization of the natural resources of the nation, places major emphasis on such questions as have just been enumerated, in many states much attention is given to other matters which are essential elements in arriving at reliable judgments. As examples of these may be cited the bearing of land values, taxation and tax delinquency on the actual and the potential use of various types and areas of land. In some states planning with respect to the social resources and needs are a definite and coordinate part of the program. Here one finds attention being given to housing and living conditions, both urban and rural; problems of health and sanitation; the facilities and requirements for mental hygiene, social welfare and education, especially public-school facilities; governmental reorganization for the various units of government; landscaping and beautification of public properties. Such matters may be of quite as great concern to the rural as to the urban dwellers.

While the limits of this discussion have necessitated treatment only in somewhat broad categories, it will be obvious that before even tentative plans can be formulated in any major segment of the field, extensive and varied bodies of detailed facts must be assembled and analyzed. Much of the basic factual material is available, but it requires to be brought together, integrated or correlated and interpreted. The planning agencies, however, have found it necessary to fill many gaps in essential knowledge by conducting or inspiring additional surveys and investigations.

THE POTENTIALITIES OF THE PLANNING MOVEMENT

While forty-two states have created planning boards to cooperate with the National Resources Board and their programs contain many common elements, it is inevitable that there will be much variation not only in the scope of the work and the extent of collaboration among the responsible state departments and agencies, but also in the vigor and competence with which the work is pressed. The values for agriculture, as for other interests of the respective commonwealths, will correspondingly show great variations. None the less a great new light has shone upon the possibilities and significance of agricultural planning, and facts of compelling importance are being marshalled. If the present planning movement survives, and if in even modest degree it approximates its potentialities, farming and rural life in America stand to gain in many ways vital to rural social and economic progress.

The whole movement has not only yielded vast bodies of knowledge and correlations of survey and research findings hitherto unavailable in such revealing form, but more significantly it has fostered comprehensive thinking about the land and water resources of the nation, the facts which influence agricultural prosperity and attractiveness in this country, and the place of agriculture and the amenities of rural life in any proposals for state and national development. For the first time large numbers in the population have come to see the unity of national life and the interdependence of the elements in our social economy. It should be less easy in future for certain kinds of public undertakings of questionable value or likely to serve special interests at the expense of more general interests to make headway. It should be possible to proceed with public enterprises with more confidence because of the wider horizon which the planning studies afford.

OBITUARY

OTTO FOLIN

OTTO FOLIN, who died in Boston on October 25, 1934, was a widely known biochemist. He achieved distinction by important contributions in the field of metabolism, by the inspiration and guidance he gave to many students and associates in his laboratory at the Harvard Medical School and by his skill and resourcefulness in designing numerous analytical methods which proved widely useful both in biochemical research and as valuable aids in medical practise. He will be missed by numerous colleagues and friends, who from personal contact as well as from acquaintance with his work came to regard him with admiration and affection.

Folin's career shows how a foreign-born young man with ability and determination but without either connections or financial resources found in America the means for education and the opportunity for high accomplishment in academic life. His professional work is a reminder of the paramount importance of technique and methods in the progress of science.

Otto (Knut Olof) Folin was born on April 4, 1867, in the village of Asheda in southern Sweden. His father, Nils Magnus Folin, was a tanner. His mother, Eva (Olson) Folin, a woman of ability and courage, was highly regarded over a large district which she served as the official midwife. When fifteen years old Otto joined the wave of Swedish immigration to America and went to live with his brother Axel in Stillwater, a lumber town in Minnesota. Working on farms and in a small hotel to support himself, he graduated six years later from the Stillwater High School. In 1888 he went to Minneapolis, found means of livelihood and successfully completed the undergraduate course at the University of Minnesota, receiving the B.S. degree in 1892. In the autumn of that year he entered the University of Chicago, which was just opening, as a graduate student in organic chemistry. Here, under the guidance of Stieglitz, he completed in 1896 a dissertation on Urethanes and was granted the Ph.D. degree in 1898. Deciding upon a career in physiological chemistry, he managed to go abroad and spent a year with Kossel in Marburg, another with Hammarsten in Upsala and a shorter period with Salkowski in Berlin.

Returning to America in 1898 with several papers published in *Hoppe-Seyler's Zeitschrift,* Folin received his degree at the University of Chicago, but failed at first to find an opening in physiological chemistry, a subject then not widely appreciated in this country. The next year, however, he was appointed assistant professor of analytical chemistry at West Virginia University. With this opening into academic life, he married in September, 1899, Laura Churchill Grant, of St. Paul. He remained at West Virginia only one year, but gave there a course in physiological chemistry which so aroused the interest of his students that several of them (including the writer) decided to attempt careers in the subject.

In 1900 Dr. Edward Cowles, superintendent of the McLean Hospital for the Insane at Waverley, Massachusetts, invited Folin to establish there a research laboratory for the study of chemical problems related to mental disease. This was probably the first laboratory for biochemical research to be established by a hospital in this country. Folin soon concluded that the most hopeful approach to the problem was a careful and detailed study of metabolism, of normal as well as abnormal subjects, for which the facilities of the hospital were admirably suited. The work led to little of value to psychiatry, but paved the way for important advances in the field of nutrition and especially in other branches of clinical medicine. The value of its results to the McLean Hospital is indicated by the continuance of that laboratory.

Folin's first object was to determine accurately the quantities of the main constituents of the urine as an index and measure of the chemical reactions within the body which produce them. Most of the urinary constituents were then known qualitatively, but methods for their determination were in many cases so laborious or complicated that no approximately complete analysis of a single urine specimen had been accomplished, and complete consecutive daily analyses during a metabolism experiment were impossible. He, therefore, undertook the task of simplifying procedures for quantitative analysis of urine.

Among the methods Folin then devised was a *colorimetric* process for creatinin and creatin, notable not only because it is still the only one available for these substances but for the reason that it introduced the *colorimeter* into biochemistry and demonstrated the practical value of color comparison as the basis for analysis of small amounts of material. This instrument found wide application by Folin and by many others.

The use of his new methods for quantitative analysis in experiments with human subjects taking diets of known composition yielded results reported in a classic paper on "Laws Governing the Composition of Normal Urine" (1905). His interpretation of these data led to a "theory of protein metabolism" which emphasized the plural nature of the process and greatly altered the views widely held at that time concerning the immediate fate of food protein in the animal body. He was led to believe that food protein after digestion in the gastro-intestinal tract was absorbed, not as then supposed in the form of protein resynthesized during absorption, but directly as small amino-acid fragments.

The papers above cited together with his other work marked Folin as one of the leading biochemists of that period and led to his appointment in 1907 to the first chair of biological chemistry in the Harvard Medical School. There for twenty-seven years he was an inspiring teacher and with numerous assistants continued the line of investigations started at McLean.

The next step was to look within the body for the products of food protein after its digestion in the intestines. Here again methods were lacking, there being at the time apparently no reaction sufficiently sensitive to measure with accuracy the small amounts of nitrogenous materials admixed with the abundant protein of blood and tissues. The simple direct way

in which Folin (with W. Denis) surmounted this difficulty is characteristic of nearly all his work and accounts for the practicability of his methods, a quality which permits their daily use in many laboratories throughout the world. Proteins and colloidal materials were precipitated without heat, the filtrate was submitted to a micro Kjeldahl digestion and the ammonia formed was determined colorimetrically by use of Nessler's reagent. This simple but skilful combination of well-known reactions into a practical method supplied the means of proving that amino-acids are absorbed directly from the intestine (a fact established simultaneously also by other investigators) and, what is perhaps of greater importance, provided a tool for the quick and accurate measurement of retention within the body of nitrogenous waste products as a result of failing kidney function.

Following his demonstration of its clinical significance, Folin's method for the determination of blood non-protein-nitrogen was immediately adopted by a number of investigators of medical problems. Its practical value as an aid in diagnosis becoming established, facilities and personnel for the performance of this and related methods were soon established in many hospitals. About the same time Folin—and others also—introduced practical methods of chemical analysis for other constituents of blood of clinical significance (creatinin, urea, uric acid and sugar). Out of these modern techniques, the earliest now only about twenty years old, supplemented by constant improvements and innovations, there has developed the present somewhat elaborate system of clinical biochemistry, practised in some degree in almost every hospital in America and rapidly spreading to other parts of the world. Although there is the suspicion, which Folin shared, that this novelty of blood chemistry is sometimes overdone, exploited or poorly performed, it represents an important advance in medicine and surgery. Any surgeon will testify, for example, to the aid given by a knowledge of a patient's blood "N.P.N." in deciding the risk of operation or in guiding preoperative care. In medical, pediatric and obstetric practise also, the information obtained by this and other methods of blood chemistry is for some conditions now regarded as almost indispensable. In this development many besides Folin have had important part, but to him is due the credit for its inauguration as well as for some of the best methods in constant use at present.

Although his methods and their practical value constitute, perhaps, Folin's principal service, it would be unjust to leave the impression that his contributions to the concepts of biochemistry are of less importance. His revision of our ideas concerning protein metabolism was fundamental and no less valuable because similar conclusions were reached simultaneously by others.

Folin took an active interest in the American Society of Biological Chemists, which he helped to found in 1906, and of which he was vice-president (1908) and its third president (1909). He regularly attended its meetings and took part in its programs as well as those of the Physiological and Pharmacological Societies, of which also he was a member.

Folin's early work appeared in *Hoppe-Seyler's Zeitschrift*, in which both his first (1897) and his last (October, 1934) papers were published, and in the *American Journal of Physiology*. After the establishment of the *Journal of Biological Chemistry* in 1905, most of his papers were sent to it. A member of its first group of collaborators, he became chairman of the editorial committee in 1920, when that journal became the property of the society. He remained until his death active and influential in the relations of the journal and the society. For many years Folin has been a member of the National Board of Medical Examiners, in charge of its examinations in biochemistry.

Among the honors bestowed upon Folin were: membership in the National Academy of Sciences; honorary membership in the Medical Society of Sweden; the honorary degree of Sc.D. conferred by Washington University (1915) and by the University of Chicago (1916); honorary M.D. by the University of Lund (1918); and the Scheele medal of the Stockholm Chemical Society (1930).

On the personal side Folin had admirable and lovable traits. Quiet and shy in manner, he did not seek wide acquaintance with people, but devoted his energy to work in his laboratory, to his departmental colleagues, to a few close friends, with whom he loved to play golf, and to his family. He possessed a quaint humor and a sane, quiet perspective toward life and work which impressed all who knew him as the qualities of a modest kindly gentleman. He was very fond of the mountains of New Hampshire, where he spent the summer months at his cottage on the slope of Kearsarge Mountain. There at its foot he is buried.

Dr. Folin is survived by his widow, their son, Grant Folin, now in business in Detroit, and a daughter, Teresa Folin, a physician now at the Children's Hospital of the University of Chicago.

PHILIP A. SHAFFER

TRIBUTE TO PROFESSOR FOLIN[1]

MY part in this afternoon's program is to speak of Dr. Folin from a dual point of view, that of an

[1] Remarks at a memorial meeting in the Harvard Medical School on November 23, 1934, at which time Professor Folin's portrait was presented.

internist acknowledging the significant value to clinical medicine and surgery of his biochemical investigations and that of a member of the medical faculty of Harvard Univeristy paying tribute to him as a stimulating teacher and leader and above all a wise, helpful and beloved colleague. Though I may not speak in mellifluous diction nor with the wisdom of the ages, I do speak with the authority of one who daily in my care of patients now for many years has utilized the methods that Dr. Folin perfected both for a better understanding of what ails sick humanity and as a guide in their therapeutic management and of one who for twenty-seven years has sat with him in faculty and committee meetings, somewhat bedevilled his peace and comfort when I used the laboratory over his head and above all in personal contacts learned to know the quality of his mind and the character of his personality.

You, my younger colleagues and students, scarce can vision medicine without the methods of blood analysis perfected by Folin and his pupils and those inspired by Folin's own accomplishments, so completely have these micro-methods of quantitative analysis become a factor integrated into the web and woof of the fabric of clinical medical and surgical lore. By such microchemical methods we follow the progress and guide the diet of those suffering from Bright's disease; using them for those approaching the period of the evils of prostatic hypertrophy, surgery has been made vastly safer; with their results at hand more successfully do we measure the needed insulin against the metabolic requirements for health in the diabetic and especially with them safely do we steer the diabetic between the Charybdis of acidosis and the Scylla of insulin shock; microchemical analysis makes possible the diagnosis of parathyroid tumors and allows the surgeon by their removal to cure serious bone disease or stay the formation in some of renal stones. Folin's studies and microchemical methods of analysis have granted us a better understanding of gout and enlightened us on the mechanism of edema in anemia, renal disease, circulatory failure and a large group of nutritional disorders.

Not all the methods have been the product of Folin's own hand or originated in Folin's laboratory, but it has been, however, from his own ingenious methods and the wisdom of his approach to important biochemical problems that has grown the whole range of microchemical analyses of the blood and other body fluids which are daily in use in hundreds of hospitals and thousands of doctors' offices the world over. He was the recognized leader in this phase of clinical laboratory technique, and some of his own methods are probably always in use, for, as it has been said of the British Empire that the sun never sets upon it, so the sun somewhere always is shining on the laboratory determining something in the blood of patients by a Folin method. As has the microscopist, so has Folin dealt with the very small, and his work has been determining accurately smaller and smaller amounts of various substances in the smallest possible bulk of blood or other body fluid. The ultimate in this would seem to be the determinations by Richards and his pupils of glucose, sodium chloride, urea, uric acid and creatinin in the fluid from a single glomerulus and from a single tubule of the kidney using micro-methods, based on Folin's investigations and perfected as a result of the guiding stimulus of Folin's work.

When Folin entered the faculty of medicine it was composed of just under 50 members. Of those men besides myself, only Cannon, Bremer, Lewis and Joslin remain in active service. We are Folin's oldest faculty friends and longest have had the stimulus of his work and his ideals, the benefit of his wisdom and the fellowship of himself. In this we have been particularly the elect, but in these intervening years many others have come to share him with us, until last year his influence was felt by 130 faculty colleagues.

Folin now is a fine tradition in the Harvard Medical School not alone to the faculty but to the members of twenty-six classes of medical students that in his laboratory have been instructed in biochemistry; his personality, his character, his wisely critical attitude toward men and their investigations, his friendly helpfulness to others, the restraint of his spoken word not failing in clarity, his modesty, his sense of humor and other qualities have endeared him to us.

In his death we have lost a truly wise colleague who was an ideal professor. Long will the memory of him remain a potent factor in our individual activities. That he lived and worked here among us is a cause of deep gratitude in the hearts of each and all of us, faculty and students of the Harvard Medical School.

HENRY A. CHRISTIAN

SCIENTIFIC EVENTS

THE CONSTRUCTION OF A BARRAGE ACROSS THE TIGRIS

THE construction of the barrage across the Tigris at Kut has been inaugurated by the Government of Iraq. The consulting engineers for the works are Messrs. Coode, Wilson, Mitchell and Vaughan-Lee, Westminster, and the contract was awarded in September to Messrs. Balfour, Beatty and Co., Limited, who expect to complete it within three years. A

cording to the London *Times*, the estimated cost is over £1,000,000.

The plan provides for a barrage and a navigation lock on the Tigris at Kut and, higher up the river, a head regulator and a canal through which the waters of the Tigris will be diverted as required into the Shatt-el-Gharraf. This river, the course of which is southward to Nasiriyeh, on the Euphrates, at present runs dry when the level of the Tigris is low in the summer season, and the object of the works is to ensure a continual flow of water throughout the year. With the installation of pumps it will thus be possible to irrigate an immense area of land which, properly watered, has rich possibilities for the production of wheat and maize and cotton.

The barrage will be nearly 2,000 feet long with its approaches and will have 56 openings, each nearly 20 feet wide, controlled by sluice gates. Its height will be nearly 50 feet from the bottom of its concrete base to the road along the top. This road, 13 feet wide, will serve as a much-needed public bridge. The navigation lock will have an effective length of 260 feet and a width of 53 feet, and as the Tigris is used extensively by a species of salmon, a fish ladder, the first structure of its kind in Iraq, will be embodied in it, to allow the passage of fish up the stream. The Shatt-el-Gharraf Canal will be 3,250 yards in length and 90 yards in bed-width.

The Tigris Barrage is one of the three big irrigation works included in the Capital Development Works program of the Government of Iraq, which, originally in the nature of a five-year-plan, was passed into law in 1931. The first of these projects was the Habbaniyah Escape, one of the principal irrigation schemes proposed by the late Sir William Willcocks some years before the war. Its primary object was to provide an escape for the spring flood of the Euphrates by diverting it into the Habbaniyah Lake on the right bank of the river between Fallujah and Ramadi, at the upper end of the cultivable lands. The water level in the river then could be controlled south of Ramadi and thus the flooding of the river year by year, with the consequent heavy damage, would be almost entirely eliminated. The other scheme is the Abu Ghuraib Canal, a smaller operation, which is now under way. The line of this canal runs from the left bank of the Euphrates about six miles below Fallujah towards Baghdad. It is 40 miles long and is expected to water about 120,000 acres.

The Government of Iraq also contemplates the erection of a dam on the River Diala, at a point where it passes through hills about 70 miles north-east of Baghdad. The effect of this work would be to form a reservoir capable of raising the river's level in the summer months and thus of irrigating 1,500,000 acres of land suitable for cotton and wheat between Diala and Kut, the cost of which would probably be more than £1,000,000.

THE DROUGHT AND AUTUMN RAINS

OVER most of the interior states, the three fall months changed completely the weather picture of the preceding winter, spring and summer, so far as moisture is concerned, according to a statement made by J. B. Kincer, of the U. S. Weather Bureau. In many areas where unprecedented drought had hung on from the first of January until the last of August abundant rains fell in September, October and November. Even with the heavy fall precipitation, however, subsoil moisture remains deficient and the average rainfall for the year is bound to be below normal in many sections where the drought was most severe.

Above-normal temperatures in every state also distinguished the autumn of 1934. Very rarely are all the states on the same side of the normal temperature mark at one time. As a rule when one part of the country is warmer than normal, some other part is colder than normal.

The fall rains that turned the tables in the heart of the drought area brought approximately one and a half times the normal precipitation to states that for the preceding eight months had averaged about one half of normal. Thus, in Iowa precipitation was only 65 per cent. of normal for the eight months from January through August, but rose to 150 per cent. for the three-month period from September to November. In Nebraska the corresponding change was from 50 to 103 per cent.; in Kansas, from 57 to 134 per cent.; in Missouri, from 59 to 164 per cent., and in Illinois, from 67 to 154 per cent. The average precipitation for the year so far—which Mr. Kincer states is not likely to change materially between now and January 1, 1935—is 86 per cent. of normal for Iowa; 69 per cent. for Nebraska; 75 per cent. for Kansas; 85 per cent. for Missouri, and 90 per cent. for Illinois.

While the Middle West and the Central Valley were being well watered the eastern Ohio Valley was dry. Ohio, after a moderately dry summer, had only 80 per cent. of normal rainfall for September, October and November. The far Southwest and the northern Great Plains also continued dry through the fall. North Dakota, for example, had only 68 per cent. of its normal precipitation, following a 52 per cent. normal rainfall for the preceding eight months. This means an average annual rainfall of just a little more than half normal for North Dakota.

The Southwest started the year dry and stayed dry. Colorado had 67 per cent. normal rainfall from January through August and 62 per cent. for the rest of the year. In Utah the corresponding percentages were 63 and 90; in Arizona, 81 and 54, and in New Mexico, 69 and 66.

Fall rains were abundant in the Middle Atlantic States and in the Mississippi Valley States. Several of these had approximately one and a half times their normal precipitation—Wisconsin, 170 per cent. of normal; Maryland, 164 per cent.; Virginia, 152 per cent., and Mississippi, 148 per cent.

The East also had plenty of rain this fall, almost enough to make up for the lack earlier in the year. Georgia and Florida were the only exceptions. These two states were seriously dry the latter part of the fall.

THE PRESIDENCY OF THE AMERICAN CHEMICAL SOCIETY

As announced in last week's issue of SCIENCE Professor Edward Bartow, of the State University of Iowa, has been elected president of the American Chemical Society for 1936, serving as president-elect during 1935. He was elected from among six candidates nominated by the local sections. The names of these nominees, with biographical sketches, as printed in the news edition of *Industrial and Engineering Chemistry,* are as follows:

EDWARD BARTOW, 64 professor and head of the department of chemistry and chemical engineering, State University of Iowa, Iowa City, which post he has held since 1920. A graduate of Williams College, he received his doctorate from the University of Göttingen and his D.Sc. from Williams College. He has taught at Williams, the University of Kansas and the University of Illinois. He was director of the State Water Survey at Illinois from 1905 to 1917 and chief from 1917 to 1920. He served as lieutenant colonel in the Sanitary Corps, U. S. A., on duty in France, and he has been a member of several important commissions, has been prominent in the work of a number of scientific organizations and has held office in several of these. He has been active in the International Chemical Union, serving as councilor, and at Madrid he was elected vice president for the United States and was made a corresponding member of the Spanish Academy of Science. Dr. Bartow has served the American Chemical Society in many capacities and at present is a member of the board of directors.

W. D. HARKINS, 60, professor of chemistry at the University of Chicago, where he has served as a member of the faculty since 1912. He is a graduate of Stanford University, and received his doctorate there too. He studied also at the University of Chicago and at Karlsruhe. He taught at Stanford and at the University of Montana before going to Chicago, and in 1910 he was research associate at the Massachusetts Institute of Technology. He has served as lecturer at the Mellon Institute and at the University of Illinois, has been consulting chemist for the U. S. Bureau of Mines, and was special agent of the Department of Justice on smelter smoke investigations in 1910–12. He has performed extensive public service, being president of the Missoula Board of Health, and still serves on the Chicago Committee on Ventilation. In 1928 he received the Willard Gibbs Medal of the Chicago Section of the American Chemical Society. He is a member of the National Academy of Sciences, the Philosophical Society, and served as vice president of the American Association for the Advancement of Science in 1920. His work in the field of physical chemistry is outstanding.

ARTHUR J. HILL, 46, chairman of the department of chemistry at Yale University since 1927. He is a graduate of Yale, where he received his Ph.D. in 1913, and since that time he has been connected with the faculty of the university, beginning his service as an instructor, following the completion of his work for the advanced degree. He is a member of the committee on hypnotics and chairman of the Subcommittee on Local Anesthetics of the National Research Council. He served in the Chemical Warfare Service during the world war. He has long rendered valuable service to the American Chemical Society, having been chairman of the New Haven Section in 1925, of the Division of Medicinal Chemistry in 1929, and is now most active in the Division of Organic Chemistry, of which he is the secretary. His principal scientific interests lie in the field of synthetic organic chemistry, biochemistry and medicinal products and dye intermediates.

WALTER S. LANDIS, 53, vice president since 1922 of the American Cyanamid Company, with which he has been associated since 1912, when he became chief technologist in that organization. He is a graduate of Lehigh University, from which institution he also received his master of science degree and the D.Sc. He was a student at Heidelberg 1905–6 and in Aachen in 1910. He was an assistant in metallurgy at Lehigh 1902–4 and was then advanced to an instructorship, next assistant professor from 1910 to 1912. He has served as chairman of the New York Section of the American Chemical Society, also of the Electrochemical Society of which he was president in 1912. He holds membership in the American Institute of Mining and Metallurgical Engineers, the American Institute of Chemical Engineers, and is well known for his research and developments in nitrogen fixation, fertilizers and electric furnace products.

A. S. RICHARDSON, 44, in charge of chemical research of the Procter and Gamble Company since 1921. His training was received at Princeton University, where he received his A.B. in 1913, his A.M. in 1915 and Ph.D. in 1927. He was an instructor in chemistry at Princeton from 1915 to 1917 and again from 1919 to 1920. He was a member of the research staff of E. I. du Pont de Nemours and Company from 1920 to 1921. Dr. Richardson was president of the American Oil Chemists Society in 1931. Besides his activities in the American Chemical Society and the Oil Chemists Society, he is a member of the American Association for the Advancement of Science and of the Chemische Gesellschaft. His scientific interests lie in the fields of catalysis, fats, and soap.

E. R. WEIDLEIN, 47, director of Mellon Institute of Industrial Research since 1921. He is a graduate of the University of Kansas, where he was a fellow from 1909 to 1912, receiving his A.M. in 1910. Tufts College awarded him the honorary D.Sc. in 1924, and the University of Pittsburgh the LL.D. in 1930. He was a senior industrial fellow of the Mellon Institute, a director of the experimental plant from 1912 to 1916 when he became associate director. Dr. Weidlein has been active in a great many scientific enterprises. He has

served as chairman of the Pittsburgh Section of the American Chemical Society, as its councilor, as vice chairman of the Division of Industrial and Engineering Chemistry. He has been president of the American Institute of Chemical Engineers, as well as a director of that organization. He has been active in the Society of Chemical Industry, the Electrochemical Society, is a member of the Franklin Institute, the Faraday Society, various academies and similar organizations, including a number overseas. While for some years he has, of course, been fully engaged in matters of organization and the advance of the institute of which he is the director, he formerly had a special interest in heat insulation materials, hydrometallurgy, camphor and epinephrine. More recently his specialty has been industrial research methodology.

FRANK C. WHITMORE, 47, dean of the School of Chemistry and Physics, Pennsylvania College, since 1929. He graduated from Harvard University in 1911, took his A.M. in 1912 and his Ph.D. in 1914. He has been a member of the faculty at Williams College, Rice Institute, the University of Minnesota and Northwestern University, where he was head of the department from 1925 until 1929. Dr. Whitmore has been active in many scientific fields. He has served as chairman of the Division of Chemistry and Chemical Technology of the National Research Council and as a member of other divisions of that organization. He was a consultant of the Bureau of Chemistry and Soils and of the Chemical Warfare Service. He has found time to assist a number of publication enterprises, including the Encyclopedia Britannica and Organic Syntheses. He was a councilor of the International Chemical Union in 1931, is a member of a number of important chemical organizations, and has been devoted to the interests of the American Chemical Society. He has served as councilor of the Chicago Section, councilor-at-large, secretary and chairman of the Division of Organic Chemistry, and is now a director of the society.

SCIENTIFIC NOTES AND NEWS

BRITISH birthday honors conferred on December 3 include knighthood on Dr. Charles Vernon Boys, physicist, the Imperial College, London; Dr. Edward Bagnall Poulton, Hope professor of zoology at the University of Oxford; Dr. John Boyd Orr, director of the Rowett Institute for Research in Animal Nutrition, Aberdeen, and Professor Walter Langdon Brown, of St. Bartholomew's Hospital, London. Sir Holburt Jacob Waring, president of the Royal College of Surgeons, is advanced to a baronetcy. Dr. John S. Plaskett, director of the Dominion Astrophysical Observatory, Victoria, B. C., is made commander of the Order of the British Empire.

AT the annual meeting of the British Mathematical Association, which was held in London on January 7 and 8, under the presidency of A. W. Siddons, the following were nominated for election as honorary members: Professor E. Borel, of the University of Paris; Professor G. H. Hardy, of the University of Cambridge; Professor David Eugene Smith, of Columbia University, and Professor E. T. Whittaker, of the University of Edinburgh.

DR. A. HAMILTON RICE, professor of geographical exploration and honorary curator of South American archeology and ethnology at Harvard University and president of the French Institute in the United States, has received the cross of the Legion of Honor from the French Government in recognition of his services for France during the war and his activities in the field of science.

A PORTRAIT of Dr. Charles H. LaWall, dean of the Philadelphia College of Pharmacy and Science, was presented to the college on December 5, by the artist, Leon A. Spielman, a graduate of the school and a practicing pharmacist.

DR. WILLIAM H. PARK, head of the Bureau of Laboratories of the New York City Health Department, observed his seventy-first birthday on December 30.

IN recognition of his work in soil science, the jubilee of Professor W. R. Williams, of the Timiriaseff Agricultural Academy at Moscow, was celebrated on December 20 by the Academy of Agricultural Science at Leningrad.

THE Karl Sudhoff medal has been awarded by the German Society of the History of Medicine, Natural Sciences and Technique to Professor T. György, professor of the history of medicine in the University of Budapest.

THE degree of doctor *honoris causa* of the University of Paris was recently conferred on M. C. E. Guillaume, director of the International Bureau of Weights and Measures at Sèvres.

ACCORDING to *Nature,* Sir Arthur Evans, at a meeting of friends and colleagues on December 17 held at the Society of Antiquaries, was presented with a portrait bust of himself in marble in recognition of his services to archeology, and in commemoration of the completion, in a fourth and final volume, of his work on the excavation of the Minoan site of Knossos in Crete. The bust is the work of Mr. David Evans, a former Rome scholar in sculpture. It represents Sir Arthur in academic robes and wearing the medal of the Society of Antiquaries, of which he was the first recipient. Lord Rennell presided, and Professor

R. M. Dawkins recounted the more notable achievements of Sir Arthur's career.

FRIEDRICH PASCHEN, the German spectroscopist, will celebrate his seventieth birthday on January 24. A correspondent writes: "Professor Paschen has spent most of his scientific life in Tübingen, where he became the teacher of numerous outstanding spectroscopists throughout the world. In 1925, he became president of the Physikalisch Technische Reichsanstalt. Paschen's infra-red hydrogen series, his discovery of the relativistic hyperfine structure of the hydrogen lines, his magnetic transformation effect in collaboration with Back, and his studies on the complex spectra of helium and other rare gases laid the background for the great development of the atomic theory from Niels Bohr to Sommerfeld, Landé, Goudsmit, Uhlenbeck, and others. His relativistic H-lines became one of the most convincing proofs of Einstein's theory. It may be mentioned, also, that Pauli found his exclusion principle working late one night in Tübingen after a careful study of one of Paschen's spectra. In 1933 Dr. Paschen retired from his office to devote himself to his favorite spectroscopic problems."

THE Botanical Society of America, at its twenty-ninth annual meeting in Pittsburgh on December 27, 28 and 29, elected as corresponding members the following botanists: Sir David Prain, lately director of the Royal Botanic Gardens, Kew; Dr. G. Haberlandt, emeritus professor of botany, University of Berlin, and Dr. Alvar Palmgren, professor of botany, University of Helsinki. The following officers were elected: *President,* Dr. Aven Nelson, University of Wyoming; *Vice-president,* Dr. K. M. Wiegand, Cornell University. Other officers of the society are: *Secretary,* Loren C. Petry, Cornell University; *Treasurer,* H. A. Gleason, the New York Botanical Garden. Officers of the sections of the society, elected or announced at the same meeting, are: Physiological Section, *Chairman,* S. H. Eckerson, Boyce Thompson Institute; *Secretary,* E. F. Hopkins, Cornell University; Systematic Section, *Chairman,* J. M. Greenman, Missouri Botanical Garden.

THE American Anthropological Association at its annual meeting at Pittsburgh elected the following officers: *President,* Robert H. Lowie, University of California; *First Vice-president,* Nels C. Nelson, American Museum of Natural History; *Second Vice-president,* Matthew Stirling, Bureau of American Ethnology; *Secretary,* John M. Cooper, Catholic University of America; *Treasurer,* C. B. Osgood, Yale University; *Editor,* Leslie Spier, Yale University; *Associate Editors,* C. B. Osgood, Yale University; Frank G. Speck, University of Pennsylvania; F. H. H. Roberts, Jr., Bureau of American Ethnology; M. J. Herskovits, Northwestern University; *Executive Committee,* W. D. Wallis, University of Minnesota; Fay-Cooper Cole, University of Chicago; Carl E. Guthe, University of Michigan.

AT the annual meeting of the Association for Research in Nervous and Mental Diseases, Dr. Edwin G. Zabriskie, of the Neurological Institute of New York, was elected president to succeed Dr. Lewellys F. Barker, of the Johns Hopkins University Hospital. Dr. Charles H. Frazier, of University Hospital, Philadelphia, was elected first vice-president; Dr. Thomas K. Davis, second vice-president; Dr. Angus M. Frantz, secretary-treasurer, and Dr. Clarence C. Hare, assistant secretary.

THE Royal Astronomical Society of Canada elected officers for 1935 at the annual meeting held at the University of Toronto on January 8. The Honorable Dr. Leonard J. Simpson, minister of education for Ontario, was elected honorary president. Dr. Lachlan Gilchrist, professor of geophysics in the University of Toronto, was returned to the president's chair for a second term. Vice-presidents elected were: Dr. Ralph E. DeLury, Dominion Observatory, Ottawa, and Dr. J. A. Pearce, Dominion Astrophysical Observatory, Victoria. R. A. Gray, Toronto, was reelected general secretary and librarian, and J. H. Horning, general treasurer.

Nature reports that Sir Isidore Salmon, chairman and managing director of Messrs. J. Lyons and Company, Ltd., has been elected president of the British Decimal Association, in succession to Lord Hirst.

DR. MACGREGOR SKENE, reader in botany at the University of Bristol, has been appointed Melville Wills professor of botany in succession to the late Professor O. V. Darbishire.

DR. HUGH C. MCPHEE, who has been in charge of investigations in genetics in the division of animal husbandry of the Bureau of Animal Industry, U. S. Department of Agriculture, for the past eight years, has been appointed chief of the division.

DR. RICHARD P. STRONG, professor of tropical medicine at the Harvard Medical School, has been named a member of the board of trustees of the Carnegie Institution of Washington.

DR. JOHN M. T. FINNEY, professor emeritus of surgery of the Johns Hopkins University School of Medicine, has been appointed a consultant to the Baltimore City Health Department.

THOMAS ROWATT has been appointed director of the Royal Scottish Museum, Edinburgh, in succession to the late E. Ward.

DR. JOHN BURDON SANDERSON HALDANE, professor of genetics in the University of London, arrived in New York on January 1. He will give series of lectures at Columbia University, at the New School for Social Research, and in Chicago. The general subject of these lectures will be "The Popularization of Human Biology."

THE fourth Harvey Lecture will be given by Dr. Alfred N. Richards, professor of pharmacology at the University of Pennsylvania, on "Processes of Urine Formation in the Amphibian Kidney" at the New York Academy of Medicine on January 17 at 8:30 P. M. The fifth lecture, on February 2, will be given by Dr. E. C. Dodds, director of the Courthauld Biochemical Laboratory of the Middlesex Hospital, London, on "Specificity in Relation to Hormone and Other Biological Reactions."

DR. CHAUNCEY D. LEAKE, professor of pharmacology of the Medical School of the University of California, delivered the annual Phi Beta Pi Lecture on November 6 at the School of Medicine of Vanderbilt University.

DR. HARLOW SHAPLEY, Paine professor of practical astronomy and director of the Harvard College Observatory, spoke at recent meetings of the Harvard Club of Lowell, the Harvard Club of Cleveland and the Harvard Club of New York City. Dr. Edwin B. Wilson, professor of vital statistics at the Harvard School of Public Health, also spoke at the Cleveland meeting. On January 12, Professor Shapley will deliver a public address in Milwaukee, under the auspices of the local Harvard Club, and on January 14 will address a meeting of the Harvard Club of Chicago.

DURING the week of December 10 Professor R. Adams Dutcher, of the department of agricultural and biological chemistry of the Pennsylvania State College, addressed sections of the American Chemical Society at Dayton and Cincinnati, Ohio; Lafayette and Indianapolis, Indiana, and Lexington, Kentucky. His lectures dealt with "Some Impressions of Biochemical Research Work in Germany and Neighboring Countries."

DR. LACHLAN GILCHRIST, professor of geophysics in the University of Toronto, will deliver the presidential address before the annual conversazione of the Royal Astronomical Society of Canada which will be held in the McLennan Physics Laboratory of the university on Tuesday evening, January 15. He will speak on "Physics in the Service of Astronomy." At the same meeting experiments demonstrating the use of physics in astronomical fields will be conducted by Dr. R. K. Young, of the Dunlap Observatory, and members of the staff of the departments of physics and astronomy of the University of Toronto.

THE first International Congress on Gastro-Enterology is being planned for August 8, 9 and 10, at Brussels, Belgium, under the presidency of Dr. J. Schoemaker, The Hague. The secretary general is Dr. George Brohee, Rue de la Concorde, 64, Brussels. Dr. Max Einhorn, New York, is forming an American committee, of which he is chairman and Dr. DeWitt Stetten, New York, secretary.

THE tenth International Congress of the History of Medicine will be held at Madrid from September 23 to 29, under the presidency of Professor Gregor Marañon.

AS previously announced, the fifteenth International Physiological Congress will take place in Leningrad and Moscow from August 9 to 17, under the presidency of Professor Ivan P. Pavlov. A reception will be held in Leningrad on the evening of August 8, to be followed by plenary and sectional meetings during the next eight days. On the night of August 16 members will travel to Moscow where, on the following day, further plenary and scientific sessions will be held and also the closing assembly of the congress. The Soviet committee in connection with Intourist Company, the travel company of the U. S. S. R., has arranged to provide transportation, meals and lodging in the Soviet Union at considerably reduced rates to members of the congress. All applicants from the United States and Canada are requested to communicate with the Arrangements Committee of the Fifteenth International Physiological Congress, in care of Intourist, Inc., 545 Fifth Avenue, New York, N. Y., for a booklet giving details of the arrangements and the various tours, costs, etc., and an application blank. All persons, other than members of the Federation of American Societies of Experimental Biology, interested in attending the congress as members, will be passed for eligibility after their applications have been submitted to the arrangements committee. Approved delegates will receive an admission card to the congress together with the Intourist travel orders. Those accepted as members of the congress will be entitled to special rates. Others wishing to attend as observers may do so by purchasing regular Intourist services, information concerning which may be obtained from local travel agents.

THE seventy-fifth anniversary of the foundation of the Liverpool Geological Society, as reported in *Nature*, was marked by a scientific conversazione, under the presidency of Dr. R. G. Wills, held on December 11 in the department of geology of the University of Liverpool. The assembly commenced with the reading of the minutes of the first ordinary meeting of the

society in 1859, after which the society's Medal was presented to Mr. Emil Montag, Swiss consul in Liverpool, for services rendered to the society during his twenty-four years' active membership, his editorship, his contributions to British and Swiss geology and his work in providing facilities for study in Switzerland. Professor H. H. Read, Herdman professor of geology in the University of Liverpool, vice-president of the society, then delivered a short lecture on earthquakes, followed by a demonstration of the university seismograph. Dr. E. Neaverson lectured on paleontological exhibits, and there was a demonstration of rock-cutting and of new maps. Amongst the exhibits was a collection of fossils, new instruments and minerals, the latter including specimens of two new British minerals recently found in Scotland; chondrodite, found in association with metamorphic limestone, and stichite, found in association with ultra-basic rocks.

LEGISLATION to enable the dairy industry of California to make and enforce marketing agreements in the state, is to be proposed in the forthcoming session of the legislature by the Dairy Control Legislative Committee, of which W. J. Kuhrt, of Los Angeles, is chairman. To prepare the proposed laws, an advisory drafting committee has been named, with F. H. Abbott, of the dairy industry division of the University of California at the Branch of the College of Agriculture, as chairman. Other members of the committee are: A. A. Brock, director of the State Department of Agriculture; F. T. Robson, chairman of the California Farm Bureau Dairy Department; G. E. Gordon, dairy specialist of the University's Agricultural Extension Service; M. R. Benedict, acting director of the Giannini Foundation of the College of Agriculture; J. H. Kagler, of the California Milk Institute; Stewart Westover, of the Evaporated Milk Agreement, and J. W. Pauluchi, dairy producer. The bill will be prepared in two parts, one covering market milk and the second covering the various other dairy products. It will be based on consumers' areas, rather than on production.

DISCUSSION

THE NATURE OF ENZYMES

I AM obliged to Professor James B. Sumner[1] for concluding his criticism of my note on "Enzymes, Vitamins, and the Zone of Maximum Colloidality"[2] with reference to the subsequent paper of H. Theorell,[3] for this is confirmation and extension of the experimental evidence (though Dr. Sumner says none exists) favoring the possibility (suggested by me but considered improbable by Dr. Sumner) that excessive kinetic activity might be a factor in reducing enzyme efficiency. Those familiar with the ultramicroscopic behavior of particles of colloidal dimensions (including enzymes) realize that when flavine/protein complexes are split, the higher particulate activity of the fragments might be a factor tending to reduction of enzymic action. This does not, of course, exclude the operation of other factors which I mentioned as basic, *e.g.*, the annihilation of, or unfavorable orientation of specific electronic areas.

Similar failure to understand physico-chemical factors appears in Dr. Sumner's attack[4] on the carrier or *Träger* theory of Willstätter. Deprecating the analogy drawn by Waldschmidt-Leitz[5] between "one of our best known proteins, namely hemoglobin," and catalase, Dr. Sumner states: "If the carrier acted merely as a protective colloid, then hematin suspended in almost any lyophylic colloid should possess high catalase activity; such, however, is not the case." Here Dr. Sumner has bludgeoned a straw man and shown himself oblivious to the vital factor of molecular orientation, developed in the researches of W. B. Hardy, I. Langmuir, W. D. Harkins, N. K. Adam and many others.[6] It is well known that many colloidal protectors inhibit catalytic action. Only such carriers can be effective as hold a prosthetic group in proper orientation, and/or serve to form or complete a specific electronic area.

Willstätter[7] has recently proposed the term *"symplex"* for compounds where high-molecular substances are bound by residual valencies—*e.g.*, a prosthetic group and a high-molecular carrier. Symplexes are distinguished from mere mixtures by one or more of the following characteristics: (1) alteration or enhancement of specific reactivity of one component; (2) change in solubility or dispersion of one component; (3) change in optical properties; (4) change in stability; (5) change in toxicity; (6) change in reactions, *e.g.*, color reactions. Among the symplexes discussed are enzyme compounds with substrates, activators, inhibitors and adsorbents; toxin-antitoxin; hemoglobin; and O. Warburg's oxidation enzyme (which was considered by Theorell[3] and by me.[2]

[1] SCIENCE, 80: 429, 1934.
[2] SCIENCE, 80: 79, 1934.
[3] *Biochem. Zeit.*, 272: 155, 1934.
[4] SCIENCE, 78: 335, 1933.
[5] SCIENCE, 78: 189, 1933.

[6] Early in this century Devaux (see review in Smithsonian Annual Reports, 1913) showed that if a lens of fatty acid is allowed to chill on water and is then carefully dried, the air/acid interface repels water, whereas the water/acid interface can be wetted.

[7] Willstätter and Rohdewald, *Zeits. physiol. Chem.*, 225: 103–24, 1934. G. Bredig (*Biochem. Zeit.*, 250: 414, 1932), by adding amino groups to fibers (cellulose, wool, silk), produced catalysts which split off CO_2 from bromcamphocarbonic acid.

Close association of particles, whether considered as "chemical" or "physical," is naturally followed by changes in kinetics and surface specificities. Professor Hugh Taylor (Princeton) has shown that with many catalysts activity is mainly due to a relatively small number of very highly efficient minute areas.

Apparently, Dr. Sumner[1] quoted Theorell's paper because it reports the *crystallization* of the oxidation enzyme. Assuming that activity is not due to an adsorbed impurity, crystallization of a substance is no evidence whatever that the same substance may not form a colloidal dispersion. For many years, teachers, writers and texts have perpetuated the erroneous notion that if a substance crystallizes it can not be a colloid, despite the fact that Thomas Graham, in his pioneer papers, clearly pointed out that the same substance (*e.g.,* silica) may exist either in crystalloidal or in colloidal form. We now know that *colloidal particles may be crystalline.*[8] Graham stated: "The inquiry suggests itself whether the colloid molecule may not be constituted by the grouping together of a number of smaller crystalloid molecules, and whether the basis of colloidality may not really be this composite character of the molecule."

There is no lack of evidence that enzymes are colloidal when in active dispersion. An interesting sidelight on the states bordering on crystallinity has just been thrown by Astbury and Lomax[9] by their x-ray studies of the interaction of water and proteins, including pepsin and trypsin. Furthermore, Svedberg's ultra-centrifugal researches show how protein molecules form groups of varied size, kinetics and external residual fields of force, depending on conditions. And I must repeat: "At the lower range of the colloidal zone, we have a reconciliation between the chemical and colloidal aspects of living matter"—even if Dr. Sumner refuses to be reconciled. Scientists should not attempt to force nature into a stoichiometric strait-jacket.

JEROME ALEXANDER

THE DENSITY OF WATER IN RELATION TO ITS THERMAL HISTORY

THERE has recently been accumulated a considerable body of experimental data[1] which is now being interpreted on the assumption that water which has shortly before been ice (called ice water) has an internal structure different from water which has shortly before been steam (called steam water). It is postulated that ice water at a definite temperature contains a greater proportion of the polymerized or bulky molecules of water than does steam water at the same temperature; this difference in extent of polymerization gradually decreasing with time until both the ice water and steam water become identical.

It has occurred to us that an unambiguous test of these assumptions could be made by measuring the density of ice water and steam water by the methods which we have been using in connection with another research.[2] Since "trihydrol" is supposed to have a density of 0.88 and "dihydrol"[3] 1.08942, and since we can measure relative densities with an error not greater than one part per million (p.p.m.), it is evident that we should be able to detect a slight difference in the percentage of trihydrol. A study of the densities of ice and steam water was chosen for the reason that the presence of impurities would increase the density of water, whereas the presence of a greater proportion of the trihydrol would decrease the density of water.

Ordinary laboratory distilled water was redistilled from alkaline permanganate and the temperature of floating equilibrium of the totally immersed float measured at 23° C. Without removing the water from the cylinder, approximately four fifths of the water was frozen, then remelted and the temperature of floating equilibrium again determined as quickly as possible. The temperature was exactly the same as before; therefore, the freezing and melting of the water and ice produced no detectable change in the internal structure of the water. The final temperature was measured within an hour from the time that the ice melted, and a significant change in density could have been detected within half an hour. It is believed by some, however, that large block commercial ice on melting gives more trihydrol than does ice made from laboratory distilled water. Accordingly, we melted two selected blocks of clear commercial ice and within an hour from complete melting again measured the temperature of floating equilibrium. The temperature this time was higher than the two previous measurements by 0.010° C., which indicates that this ice water has a greater density than highly purified water to the extent of 2.4 p.p.m. Again there was no indication of an enhanced percentage of "trihydrol" of the ice water as compared to steam water. We conclude that the biologists and others should explain their data on hypotheses different from the hypothesis of a greater trihydrol content of ice water.

MALCOLM DOLE
B. Z. WIENER

NORTHWESTERN UNIVERSITY

[8] See, *e.g.,* P. Scherrer, *Nachr. Ges. Wissen.* Goettingen, 96, 1918.

[9] See *Chemistry and Industry,* November 16, 1934, report of Manchester meeting, on November 10, of the Chemical Society.

[1] For a recent complete bibliography and discussion see T. C. Barnes and T. L. Jahn, *Quart. Rev. Biol.,* 9: 292, 1934.

[2] M. Dole, *Jour. Chem. Phys.,* 2: 337, 1934.

[3] See note 1.

PLOUGHING UNDER THE SCIENCE CROP

IT is possible that Dr. Campbell in his recent address[1] has begged the question. The "small group of extremists" whom he mentions, advocate, not "the taking of a holiday in scientific research," but a slowing up of research efforts in order that there may be time to discover, not new things, but the meaning of things already discovered. To some the physicist and the chemist seem to be traveling so fast as not to heed or care where or how or why they are going. Nor do they heed or care what misapplications are made of their discoveries.

Indeed, not only in industrial scientific laboratories but also in some, at least, of the laboratories connected with educational institutions, the chief aim of scientific research is to enable those who already receive an undue share of the wealth produced by industry and research, to appropriate a share still larger. And there is a constant and increasing demand from educational institutions for more funds to be used by their scientific laboratories for more research for more applications for more profits for more segregation of wealth.

Is it not time to remember that there are other sciences, psychology, economics, sociology, upon the development of which the welfare of mankind depends far more than upon the development of physics and chemistry? And to remember that the development of that group of humane sciences would serve to prevent the misapplication of the discoveries of the physical sciences to the hurt, the destruction, the degradation of mankind?

Physics and chemistry boast of the improvement in man's material welfare brought about by their discoveries. True; but for thousands who are so benefited there are millions who are not, because of the distribution of wealth. These can not have even the material benefits of physical science because they can not afford to pay for them. Psychology, economics, sociology, philosophy, if adequately endowed, could alleviate these evils; could, possibly, eliminate them.

The "small group of extremists" demands a readjustment, a realignment, a redistribution of "research" and of "progress," so that man's progress shall be that of a man, not that of an octopus stretching out first one arm, then another; shall be a homogeneous progress of society as a whole; shall be a progress, material to be sure, but to an even greater degree spiritual. These are the things which the "small group" of enthusiasts, idealists demand, even if physics and chemistry must, therefore, for a time be dormant. Perhaps a "rest period" would greatly benefit those sciences themselves.

L. MAGRUDER PASSANO
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

QUOTATIONS

SCIENCE IN THE NEWS

IN the remarks preliminary to his recent address on cosmic rays Dr. Robert A. Millikan expressed some views about newspapers, his fellow-scientists and the present generation. It is almost inevitable, he said, that any new field in which there are many workers should appear to the public, and even to many of the workers themselves, to be in a state of hopeless confusion. This, he thought, is because the individual workers, unrestrained in a new field by a body of established fact, tend to set up hypotheses that seem to fit their particular experiments or their particular theories, and are themselves ignorant of, or at least incredulous about, the findings of others, so that "the public soon loses itself in a maze of incompletely understood and apparently contradictory statements and opinions, and knows not whom and what to believe." This situation, he continued, "is not improved by the existence of the daily newspaper, which, as its very name implies, is under a greater pressure to find for its pages something that is new rather than something that is true." He ventured the prediction that the present age, because of "its craze for the new regardless of the true," will be looked back upon by our grandchildren with "amazement and ridicule."

It is unusual to hear the daily newspapers criticized for printing too much news about science. The more common criticism is that they devote a disproportionate space to scandals, murders and sports, and neglect the world's constructive cultural achievements. Dr. Millikan's criticism serves to direct attention to the increasing amount of attention that the newspapers have been devoting to science, which implies a growing interest in science on the part of their readers.

Dr. Millikan ought to be the last man to deplore such a development. His statements seem to indicate that he does not believe that the newspapers ought to confuse their readers by printing news about controversial hypotheses, but this is to imply either that the newspapers should themselves set up as judges of the truth of scientific theories, refusing to print anything about new theories that they did not agree with, or that they should not print any scientific news until it had got past the controversial stage. It would be very difficult to say when this point had been reached, if it ever was, and the probable result would be to cut

[1] SCIENCE, 80: 2085, December 14, 1934.

down scientific news to the merest fraction of the present amount, or to print only such things as the multiplication table.

Dr. Millikan's own definition is that an opinion becomes established in physics "when nine-tenths of the informed and competent workers in the field are in agreement upon it," and adds that there will always be a certain percentage of people who will vote "no," and that "for no reason whatever except that they are built that way." The newspaper, however, can hardly be expected to stop to take a census before it publishes anything about a scientific theory or discovery. If it did so it would not only abandon its primary function of informing the world—including the scientists themselves—of the discovery, but it would be shutting off the views of the dissenting 10 per cent., and the history of science certainly does not show that this dissenting 10 per cent. has always been wrong.

The function of the newspaper is primarily to report what the leading scientists do and say. If they contradict each other, and there is confusion, the newspapers merely picture the confusion and do not create it. To the extent, however, that newspaper reports emphasize the contradictions among scientific theories, they increase the pressure on the scientists to eliminate these contradictions.—*The New York Times.*

SCIENTIFIC BOOKS

THE ARCHITECTURE OF THE UNIVERSE

The Architecture of the Universe. By W. F. G. SWANN. ix + 428 pp. The Macmillan Company, 1934. $3.75.

ALTHOUGH "The Architecture of the Universe" is somewhat similar in subject-matter to several other books that have appeared in recent years, it is a refreshing and original work. Its twelve chapters are devoted to such subjects as the nature of matter, modern atomic theories, space and time, dimensions, the restricted and general theories of relativity, vital processes and science and theology. The author does not presuppose extensive scientific training on the part of his readers, and consequently refrains from using the technical language of the specialist, yet he goes deeply into the fundamentals of each of the subjects he treats. Indeed, I have read no other semi-popular discussion of these subjects that presents them so adequately and satisfactorily.

In style, the book of Dr. Swann is quite different from others in its field. There is in it no striving for the sensational, no parading of the paradoxical, no mixing in of the mystical. Instead, with refreshing balance and candor, the author presents science as a sane, orderly body of doctrine developed for interpreting experience. Science as he presents it has the fine spirit we associate with the names of Archimedes, Galileo, Newton and Darwin. I can not easily overemphasize the excellence of these praiseworthy qualities of his exposition. But in mentioning them I am likely to convey the impression that the book may be dull and monotonous. As a matter of fact, it is sparkling with wit and humor, extraordinarily rich in figures of speech and extended comparisons, and livened with many fine passages. The extended comparisons or parables are not only apt but often very interesting. If they have a fault, it is that in some cases they are so long and so entertaining that the reader is likely to forget that they are only illustrations of an important and difficult scientific principle or conclusion. An example is the parable used in discussing the second law of thermodynamics.

The author has attained exceptional sparkle and variety of exposition by a remarkably successful use of an interesting device. He often sets up a discussion between himself and the reader, all expressed in direct quotations. Under this method he does not limit himself to stating his own conclusions; the reader, too, expresses his opinions, his misconceptions, doubts and antagonisms, and the author answers him. This method, of course, is not new, for it was employed by Plato and Galileo and many other writers. But Dr. Swann has used it with rare skill, being eminently fair in permitting the reader to have his say and equally fair in his replies, and illuminating all with wit and apt figures of speech.

It is not possible within the limits of space available for a review of the book to outline comprehensibly any of the particular discussions Dr. Swann has given. I must content myself with saying that his remarks upon the second law of thermodynamics, the principle of indetermination, vital processes and even the relationship between science and theology are particularly penetrating, balanced and convincing. If any of these subjects were to be omitted, I should choose the last, partly because from its nature it does not lend itself to very definite conclusions. The author does not, however, indulge in any such amateurish attempts to rest theology on science as have frequently appeared in recent years.

"The Architecture of the Universe" is a splendid book which I strongly recommend to those who desire to get a real understanding of the heart of science to-day and who are willing to devote considerable careful thought to attaining that goal.

F. R. MOULTON

A STUDY OF SUPERSTITION

Do You Believe It? By OTIS W. CALDWELL and GERHARD E. LUNDEEN. 307 pp. Doubleday, Doran and Company. 1934. $3.00.

THIS meritorious volume has a divided purpose. The one is to present a general survey of superstitions as they come down through the ages, are modified and revived, together with some account of the origins of these persistent beliefs and the habit of mind, the quality of reasoning behind them. The other is to investigate the present prevalence of beliefs in superstitions and their effect upon behavior; and in view of the finding to suggest some educational measures to counteract this incongruous and somewhat weakening trend. The two purposes are not altogether consistent, nor can they follow the same treatment and style. The reader interested in the popular aspects will not follow the statistical account; and those who read it for its more serious purpose have no need to enlarge their acquaintance with popular misconceptions.

The general survey does not go sufficiently behind the scenes to add to the philosophy of the topic; that is a far-flung inquiry in its own right. The survey includes false beliefs (such as weather signs) where there is some measure of scientific approach and also folk-lore as well as doctrinal superstitions in which this is lacking.

While these two orders of false thinking should be distinguished, it is convenient to have the two aspects assembled within one pair of covers; and this contribution by Dr. Caldwell and Mr. Lundeen serves the purpose well. It will give libraries just the book to which they can refer the general reader, who, if he reads it properly, will emerge from the exercise with a wiser view of the distinction between the cautious steps of science and the vaulting leaps of superstition, untroubled by the insecurity of premises. It makes a fine correction for the vagaries of popular belief.

The statistical study proceeds by the method of selecting 100 current superstitions and false beliefs and asking the subjects—in the initial series about 700 junior high-school pupils—to indicate whether they hold this belief or do not, whether they heed it or not in their behavior. The general result, that on the average, these students approve or assent to or are affected by as many as 22 such superstitions, indicates a rather formidable hold of false beliefs in the formative educational years. The superstitious tendency diminishes somewhat with maturity; girls are uniformly more hospitable to such beliefs than boys; the more intelligent entertain fewer superstitions than the less intelligent; the contagion of belief among friends, home and immediate surroundings is the dominant factor in their spread. Introducing corrective training in the general principles of cause and effect, as illustrated in the sciences, definitely reduces the inclination toward superstitious beliefs.

These general results, for the most part readily anticipated, are about all that the statistical method can yield. They supply a somewhat objective set of data, but do not, perhaps can not, attain any greater significance. It is true of this, as of many another painstaking study in the less concrete realms of educational psychology, that their yield is small compared to the expenditure of mental energy involved. The essence of such a problem as the spread and hold of superstitions lies in the qualitative analysis of the habit of mind conducive to their acceptance. This disappears in the mass statistics, in one respect needlessly so. Crude superstitions and false generalizations are treated as one. If separated, as they could readily be, and if furthermore within the superstitious field the more venial instances were separated from the grosser violations of logic, a step or two might be taken toward an index of superstitiousness. A comparison of the ten most generally accepted with the ten most generally rejected gives the impression—despite a rather scattered distribution—that these young ideas, which are trying to shoot straight, are mostly given to the lighter types of illogicalities.

The literature of superstition has been mainly one of anthropological interest when serious, of folk-lore curiosity when in popular vein. The psychological interest forms a chapter in the comprehensive story of how the human mind groped, stumbled, drifted, fumbled in its haphazard course in learning how to think. The conflict of psychological trends with logical precepts, pointedly illustrated in wish-thinking, explains part of it; the intrinsic difficulty of the technique outside the familiar range of events accounts for another phase. Scientific thinking does not come naturally to the popular mind; those professionally devoted to its dissemination have gone through a discipline to attain their expertness.

JOSEPH JASTROW

SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE GEAR PUMP AND HOSE AS A COLLECTOR OF WATER SAMPLES FOR GAS ANALYSIS

IN our study of the gaseous content of the waters of Chesapeake Bay and its tributaries, in connection with a biological survey, it is often necessary to take samples from a depth of 25 meters or more where the water is under much greater pressure than at the surface. It is generally known that when such samples reach the surface there is a tendency for the contained

gases to pass from the water to the atmosphere if the water is exposed. Those who have studied the gas content of samples of natural waters are agreed that precautions must be taken to protect the samples in some way if accurate analyses are to be made.

However, a review of the literature indicates that most workers have not paid much attention to the loss of gases resulting from bringing deep-water samples to the surface. It is true that Krogh,[1] using a bottle for the collection; B. Helland-Hansen,[2] discussing the use of a pump and hose; Buch and Grippenberg[3] and others state that the loss of gases is negligible. We believed that this might be the case ordinarily, but since we wanted to use the convenient pump and hose method in an extensive series of analyses for gases in water we felt it necessary to compare samples collected in this way with those collected by an apparatus where there could be no loss.

The apparatus used was constructed as described below. A 250 cc glass tonometer (Fig. 1), such as

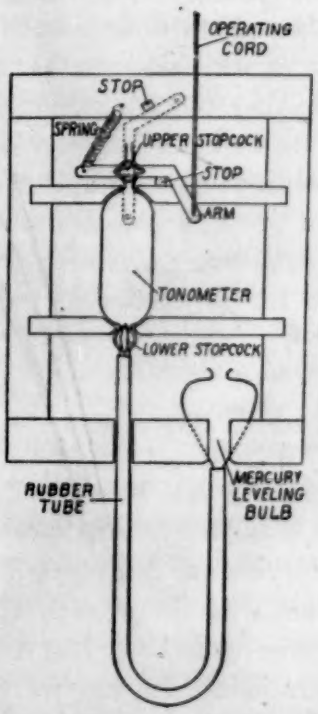

FIG. 1

the one used by Van Slyke in his gas studies, was mounted in a wooden frame of 2″ x 4″ material in such a manner that it was held in position vertically about midway in the frame. One end of the tonometer, with both stopcocks open, was connected by a heavy walled rubber tubing to a 500 cc mercury leveling bulb. The latter was slotted into the base of the frame so that it could be easily removed and replaced. About 500 cc of mercury was then poured into the mercury leveling bulb and the bulb was raised until the tonometer was filled with mercury so that no air was present, even above the upper stopcock, which was then closed. Any gases which might have been in between the mercury and the glass walls were expelled by lowering the mercury leveling bulb several times so as to produce a partial vacuum in the tonometer and then manipulating the leveling bulb and the upper stopcock, the latter being left closed finally. The leveling bulb was then returned to its place in the base of the frame. In this way the tonometer was filled with gas-free mercury.

In order to fill the tonometer with a sample of air or of water all that is necessary is to open the upper stopcock. The mercury in the tonometer then flows down through the tube into the leveling bulb in order to make the level of the mercury the same in both. When the mercury has run out of the tonometer the upper stopcock is closed. The result is a sample of air or water filling the tonometer and protected from escape above by a closed stopcock and from below by mercury.

In order to make the apparatus so that it could be opened at some considerable distance from the operator, *e.g.*, at a depth of 25 meters in the water, a metal arm was fastened to the upper stopcock. The arm was bent in such a way that a cord attached to the arm, as shown in Fig. 1 and pulled sufficiently, would rotate the stopcock through 90° and then stop. In order to close the stopcock, a stout coiled spring was attached to the other end of the arm and anchored to the top of the wooden frame. Thus the spring automatically closes the upper stopcock when the tension on the cord is released. To prevent the metal arm from moving through too wide an arc, a metal stop was placed on the top of the frame in such a position that when the arm had moved and had opened the stopcock, further rotation was prevented. Another stop was placed as shown in the figure, so that the arm would not move too far when the tension on the cord was released.

Since the apparatus just described was lowered along with the hose so that samples could be taken at the same time and depth with both the tonometer apparatus and the hose-pump apparatus it is necessary to describe the latter.

A 1-inch Oberdorfer bronze, gear pump driven by hand was used. In order to facilitate the taking of samples for different purposes, *i.e.*, for plankton and for chemical analysis, certain accessories were added. They were made of tinned brass so as to avoid chem-

[1] A. Krogh, *Meddelelser om Grønland*, xxvi: 341, 1904.
[2] B. Helland-Hansen, *Internationale Revue der gesamten Hydrobiologie und Hydrographie, Hydrographische Supplemente*, 1. Serie, 2 Heft, p. 16, 1912.
[3] K. Buch and S. Grippenberg, *Jour. du Conseil*, 7: 44, 1932.

ical interaction between the apparatus and the water samples. All the joints between the pump and the accessories were sweated shut, thus giving a continuous metallic surface. The accessories consisted of a tee, a pet cock, a gate valve, a 1-inch pipe and a piece of block tin tubing. One limb of the tee, the opening of which may be used for priming purposes, is stopped with a removable plug. After priming, the plug is tightly screwed in. A second limb was attached to the outflow opening of the pump, while the third limb with the gate valve in it served as the main outflow of water from the tee. The pet cock was sweated into the side of the third limb and the piece of block tin tubing, 12 inches long, was soldered on to the delivery end of the pet cock.

The intake end of the pump was attached to a hose reel by means of a 1-inch pipe and a ground brass swivel joint, which enables the operator to conveniently pay out as much hose as is needed and then by means of a wrench to readily make this joint leak-proof. The hose measured 1 inch inside diameter. It is necessary that all parts of the pump and its attachment to the hose should be leak-proof or serious errors will arise due to the sucking in of air.

In order to make the final preparations for the collecting of both kinds of samples at the same depth and time, the tonometer apparatus, assembled and adjusted as described above, was firmly wired to the hose alongside of its intake end. The end of the hose was weighted with 60 pounds of lead so that the hose would extend downward as nearly vertically as possible. The hose with lead and tonometer apparatus firmly wired to it at the intake end as described were then lowered to the desired depth, the operator paying out the cord with which the tonometer stopcock may be opened.

Both sets of apparatus are now ready for the collection of the sample. In the case of the tonometer the cord upon being drawn tight will open the upper stopcock and allow the water to enter, since the mercury held in the tonometer sinks in order to adjust its level to that in the leveling bulb, which is at a considerably lower level. A release of the tension on the string after 5 minutes allows the stopcock to be closed again by the spring and the sample is tightly enclosed in the tonometer.

In the case of the pump and hose apparatus, after priming and screwing in the priming plug, the pet cock connected with the block tin tube is closed, the gate valve is opened and the water pumped up until sufficient has flowed out to yield a sample which has its origin from 25 meters. The gate valve is then closed, the pet cock opened and a sample of water is delivered either under oil in a sample bottle or preferably into a tonometer such as the one used in the tonometer apparatus but without the rubber tubing, mercury and leveling bulb.

Samples of this sort, taken by the two methods, were then analyzed, within a short time, in the laboratory, using the manometric Van Slyke apparatus. The samples can be transferred to the Van Slyke apparatus without loss of gas if the usual methods in the operation of the apparatus are followed.

A comparison of the results obtained in an analysis of two samples collected by the methods outlined above are given in Table 1.

TABLE 1

	Total CO_2 p.p.m.	O_2 p.p.m.	N_2 p.p.m.
Pump	50.5	9.1	17.8
Tonometer	51.7	8.1	17.1

It will be noted that the difference in each case is about 1 part per million. Even this difference might have been due in part to the use of oil for the pump samples. Another pump sample gave closely similar results. Earlier work, however, in which less care was taken in making the pump and hose leak-proof gave a greater discrepancy in results. It is evident, however, that when the pump and hose are properly put together and properly handled the values obtained for the gases in the water samples taken will be sufficiently accurate for physiological purposes.

R. P. COWLES
CHARLES BRAMBEL
THE JOHNS HOPKINS UNIVERSITY

METHIONINE AS AN IMPURITY IN NATURAL LEUCINE PREPARATIONS

IN recent experiments dealing with the effects of various amino-acids in the growth of the diphtheria bacillus, differences have been found in the action of l-leucine preparations. It was recalled that in the early work on methionine considerable sulfur, probably as methionine, was always present in the crude "leucine fraction" of material obtained by concentrating protein hydrolysates. Two instances were also in mind of the occurrence of readily measurable amounts of sulfur in specially purified l-leucine, one of these, at least, prepared by the ester method.

Commercial l-leucine from three different manufacturers, two American and one German, were therefore examined. The two former gave strong qualitative tests for sulfur, and likewise a fairly heavy precipitate with $HgCl_2$. The latter gave only a weakly positive test for sulfur and very slight opalescence with $HgCl_2$. Quantitative sulfur determinations by Na_2O_2 fusion were as follows:

Specimen A 0.4000g gave 0.0471g $BaSO_4$ = 7.5 per cent. methionine

Specimen B 0.4018g gave 0.0573g $BaSO_4$ = 9.2 per cent. methionine

Specimen C 0.4000g gave 0.0179g $BaSO_4$ = 2.7 per cent. methionine

These three specimens were further examined as to their effect on the growth of a strain of diphtheria bacillus which requires methionine for optimal development. A control solution,[1] containing all the ingredients for growth except methionine, was prepared and additions to equal amounts were made as indicated in the table. The solutions were made up to a volume of 10 cc, adjusted to pH 7.6, and sterilized. Total nitrogens, taken as a comparative measure of the amount of growth, were made on the centrifuged and washed diphtheria bacilli growing at 35° in 60 hours on these media. The results are shown in the last column of Table I.

TABLE I

	Media			Mg N in bacterial growth
1	Control + l-leucine	A	10 mg	0.83
2	" + "	B	10 mg	1.44
3	" + "	C	10 mg	0.48
4	" + dl "	(synthetic)	10 mg	0.30
5	" + dl methionine		1.0 mg	1.80
6	"			0.35

It is therefore evident that methionine in considerable amounts may be present in commercial leucine preparations and that failure to recognize this fact may lead to complications where such material is used in biological experiment.

J. HOWARD MUELLER
HARVARD UNIVERSITY MEDICAL SCHOOL

SPECIAL ARTICLES

ELECTRICAL POTENTIALS FROM THE INTACT HUMAN BRAIN[1]

DR. HANS BERGER, of Jena, has published a series of papers in which he reports that changes in electrical potential which are correlated with human brain activity may be magnified and recorded by the use of a suitable vacuum-tube amplifying system and an oscillograph.[2] These potential changes are obtained from needle or surface electrodes placed on different points of the head. His most typical electrode arrangement is one in which needle electrodes are inserted through the skin to the periosteum, one in the back of the head to the right of the median plane and the other high on the forehead to the left of the median plane. He reports, however, that electrodes placed on the surface of the skin give results comparable to those secured by the use of needle electrodes. He holds that the records secured by the use of this general technique show, among other phenomena, two characteristic forms of rhythmic electrical oscillations. The waves of greatest magnitude he calls alpha waves. Smaller oscillations which are sometimes observed alone and sometimes as superimposed upon the alpha waves he calls beta waves. The alpha waves occur with varying frequency in normal adults, but about 10 cycles per second may be taken as a typical value. These waves may show a potential of as much as 100 to 200 microvolts when needle electrodes are used. The beta waves have a frequency of about 25 cycles per second and have a magnitude much less than that of typical alpha waves.

Berger has carried out control experiments intended to demonstrate that the electrical phenomena which he is studying are functions of brain activity and not of some other organic process. Simultaneous electroencephalograms (as he calls the records of the electrical phenomena which he considers to be correlated with brain activity) and electrocardiograms have been taken. These records demonstrate the fact that there is no direct relationship between the so-called brain waves and the pulse. Moreover, even a momentary arrest of both breathing and heart beat had no marked effect on the brain potentials. In the course of human brain surgery it has been possible for him to place electrodes directly on the brain through trephine openings. The records so taken are similar to those secured by the use of the surface electrodes. Prawdicz Neminski[3] has secured similar action potentials from electrodes on the brain of dogs, that is, waves of large magnitude at a frequency of 10 to 15 per second and smaller waves 20 to 32 per second. Adrian and Mathews[4] have recently observed similar phenomena originating in the cortex of the rabbit.

Dr. Berger has shown in these experiments that the alpha waves diminish in magnitude under certain types of anesthesia, during an epileptic seizure and, it may seem at first sight paradoxically, when the

[1] The control solution is fully described in an article now in press (*Jour. Bact.*).

[1] This research has been made possible by a grant from the Rockefeller Foundation.

[2] H. Berger, *Arch. f. Psychiat.*, 87: 527, 1929; 94: 16, 1931; 97: 6, 1932; 98: 231, 1933; 99: 555, 1933; 100: 301, 1933.

[3] P. Neminski, *Pflüg. Arch. f. d. ges. Physiol.*, 209: 362, 1925.

[4] E. D. Adrian and B. H. C. Mathews, *Jour. Physiol.*, 81: 440, 1934.

subject is given sensory stimulation or does a "mental" problem. The waves indeed appear at a maximum amplitude when the subject is relaxed. He has studied a variety of pathological cases and finds that marked changes in alpha waves are characteristic of certain abnormal brain conditions. The beta waves, however, seem, according to the report of this investigator, to remain very constant in most conditions of the organism. Dr. Berger presents an elaborate and interesting psychological discussion, couched largely in terms of an inhibition theory of attention, as an explanation for the results which he has secured. Adrian and Mathews, from their work on animals, are of the opinion that the low frequency waves are due to the summation of many smaller higher frequency potentials.

A brief statement of the technique and results of our present investigation, which has in some respects confirmed and amplified Berger's results, is given in the following paragraphs.

In most of our experiments electrodes made of silver disks 1 to 2 c in diameter, covered with flannel soaked in salt solution, are used. These electrodes are placed on the skin surface and usually at opposite poles of the head. For example, one may be placed high on the forehead and the other at the back of the head just above the inion. The electrical potentials appearing at these electrodes, when fed into a suitable amplifier-oscillograph system, confirm Berger's general observations. Notably our records show large rhythmic oscillations (alpha waves) which vary in magnitude from about 20 to 80 microvolts and in frequency from about 8 to 12 cycles per second in a normal adult during a favorable condition of relaxation and quiet. In one experiment simultaneous records were taken from a pair of needle electrodes inserted through the skin to the periosteum and from a pair of surface electrodes on the skin directly above. Using a pair of matched non-interfering amplifiers and oscillographs the two records were practically identical in form, although the potentials picked up by the needle electrodes were slightly greater.

Smaller oscillations (beta waves) are also observed at magnitudes of about 15 to 30 microvolts and with frequencies varying from 25 to 50 cycles per second. These small oscillations are quite variable in frequency and different in form from the larger alpha waves.

In addition to these potentials, which appear to be present across almost any part of the head during a quiet, relaxed state, what seems to be a different type of potential has been recorded when the subject is presented with a sensory stimulation such as a light or sound. In several instances electrodes seem to have been so placed on the head that following a given stimulation a complex series of waves appear which may possibly be thought of as the positive excitatory effect of the stimulus. Further experimentation may make it possible to identify these as excitation waves, since they resemble somewhat the action potentials taken from visual centers of animal brains following photic stimulation.

In addition to the potentials which have just been described, incidental potential shifts such as those caused by movement of the skin beneath the electrodes and short "spiked" waves of muscular action currents (about 10 σ duration) are at times recorded in the course of our experiments. These secondary phenomena are most noticeable when the subject is in a state of heightened muscular tonus or restlessness. These phenomena seem not to be present in a completely relaxed and cooperative subject who is comfortably placed in a quiet, dark room. It seems, however, that the skin and muscle potentials may be readily distinguished by their form and frequency from those potential changes which, according to Berger's theory, are to be considered as of brain origin. Similar potential changes observed by several investigators in carefully controlled experiments on animals suggest that these changes are of cortical origin.

Separate rooms for the subject and the apparatus, both well shielded against electrical disturbances, have been used in our experiments.

Fig. 1 illustrates the type of record which we have obtained from a relaxed and cooperative subject.

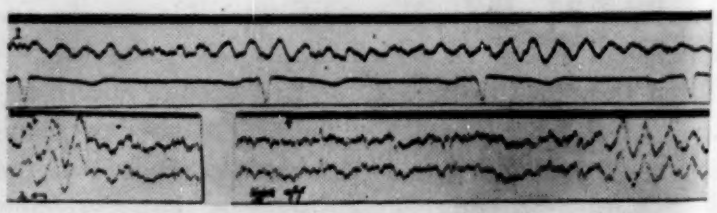

FIG. 1

The first record of Fig. 1 shows the alpha waves in the upper line and in the second line a record taken, as a control, simultaneously from electrodes placed across the left leg above the knee. A record of the pulse only is obtained in this latter curve and no relation is seen between the pulse and the simultaneously recorded alpha and beta waves.

"Spontaneous" fluctuations in magnitude of the alpha oscillations are present in all our records. When the subject is undisturbed by extraneous stimulation these fluctuations appear quite regularly at 1 to 2 second intervals. This rhythm may be seen in the sample record No. 1. We have been unable to correlate these fluctuations with any other organic rhythm. They are the type of modulations that would be produced by the interference of different component frequencies, the total effect of which we obtain

in our records. This provides indirect evidence in support of the hypothesis of Adrian and Mathews, namely, that the large oscillations are the end result of potentials built up by several smaller oscillations at different frequencies.

The second record shows two recordings of the effect of light stimulation on the large alpha waves. The two records are taken across different parts of the head. It will be noted that these waves are markedly reduced by the light stimulation after a latency of 0.4 seconds. (The time line at the top of the record indicates 1/50 second intervals. The signal indicating the period of stimulation is marked by an upward deflection of the time line). When the light stimulus is turned off, the alpha waves return to normal after a short period. The duration of this after-effect of light stimulation seems to vary with characteristics of the stimulus, such as duration. It may most tentatively be suggested that this latency in the return to normal of the alpha waves is possibly associated with the phenomenon of the visual after-image.

As noted above, it is suggested by Berger that the alpha waves may indicate a fundamental characteristic of brain activity. In our experiments on normal individuals the frequency varies little from day to day when experimental conditions are maintained constant. Characteristic frequency of different normal individuals has varied from about 8 to 12 cycles per second. In 6 individuals from whom repeated records were secured on different days, up to five repetitions, variation of not more than one cycle per second was shown in the same individual on successive measurements. In one or two pathological cases which we have studied a frequency of alpha waves as low as 2 or 3 per second has been observed. We have also demonstrated that in certain normal individuals when the electrodes are placed so as to include part of the right side of the head between one pair and part of the left side of the head between the other pair the same frequency is observed in both records and under these conditions the waves are typically in phase. Other records indicate that some normal individuals, and especially certain pathological cases, show different frequencies or a lack of synchronism between the functioning of one side of the brain and that of the other. For example, in the case of a young girl who suffers from a convulsive disorder and is quite ambidextrous, the alpha-wave frequency was observed on repeated tests to be about 10 per second across the left side of the head and but 6 to 8 cycles across the right side of the head. These records were taken simultaneously by the use of two well-matched, non-interfering amplifier-oscillograph systems.

In conclusion, we may say it has been possible for us to confirm many of Berger's observational findings. With the improvement of recording techniques and with an increased understanding of the functional relationship between the results secured and other processes of the living organism, it may well be that electroencephalograms of the sort described in this note may prove significant in psychology and clinical neurology. It is even possible that this technique may provide information in regard to brain action which will be comparable in significance to the information in regard to heart function which is provided by the electrocardiograph. Further experimental studies of the phenomena described here are in progress.

H. H. JASPER
L. CARMICHAEL

PSYCHOLOGICAL LABORATORY
OF BRADLEY HOSPITAL AND
BROWN UNIVERSITY

THE LONG WAVE-LENGTH LIMIT OF PHOTOLETHAL ACTION IN THE ULTRA-VIOLET

SINCE the earliest observations on the lethal action of sunlight by Downes and Blunt in 1877,[1] the determination of the long wave-length limit of lethal action of light upon cells has been a subject of recurrent interest, as various investigators, failing to use a quantitative technique, claimed different limits. In 1924 Coblentz and Fulton,[2] measuring the incident intensities at different wave-lengths, showed that much less energy is necessary to kill *Bacillus coli communis* at wave-lengths shorter than 3,050A than at longer wave-lengths, although lethal action extended as far as 3,660A when the dosage was exceedingly large. Few studies on the wave-length limit of lethal action have been made upon protozoan cells. Swann and del Rosario[3] report that the wave-length 3,132A is only 1 to 4 per cent. as destructive to Euglena as is the wave-length 2,536A. On the other hand, Weinstein[4] reports that *Paramecium multimicronucleata* is killed about one ninth as readily at 3,130 as at 2,654A and about one half as readily as at 3,025A comparing the lethal action on the basis of the energy incident upon the exposure cell. As this appeared to be an unusually destructive effect for the wave-length 3,130A, it was decided to investigate its effects upon this species of Paramecium as well as upon several other protozoans.

The protozoans were obtained in sufficient numbers by inoculating individuals from a local pond into 0.1

[1] Downes and Blunt, *Proc. Roy. Soc.*, 26: 488, 1877.
[2] Coblentz and Fulton, *Sci. Papers U. S. Bur. Standards*, 19: 641, 1924.
[3] Swann and del Rosario, *Jour. Franklin Inst.*, 213: 549, 1932.
[4] Weinstein, *Jour. Op. Soc. Am.*, 20: 433, 1930.

per cent. lettuce infusion, buffered at a pH of 7.0 and incubated at 26° C. in a water bath. Rapid multiplication occurred. Paramecia were cultured in the controlled manner described in another paper.[5] The quartz mercury arc, the monochromator, thermopile, reaction cells, exposure chamber and the procedure followed have been described in another paper.[6] To insure purity of light at the wave-length 3,130A, a Cornu prism was used. Usually 50 or 100 animals were exposed at a time.

RESULTS

While *Stylonychia mytilus* and *Euplotes patella* did not become vesiculated at 3,025A (average intensity for all experiments at this wave-length: 22 ergs/mm²/sec.) until a dosage of 66,000 ergs/mm² at the midpoint of the exposure cell had been given, *Paramecium multimicronucleata* became vesiculated after a dosage of about 33,000. A dosage of only 16,500 ergs/mm² is sufficient to kill the Paramecia after a lapse of 24 hours following irradiation. A dosage of about 9,300 ergs/mm² kills only a few Paramecia even after a lapse of 24 hours. Since the area of a Paramecium exposed is about 0.0106 mm² the energy incident upon a single Paramecium is the energy per mm² × 0.0106.

On the other hand, even if many times the above dosages of energy at the wave-length 3,130A (average intensity: 40 ergs/mm²/sec.) are given to these various protozoans, there seems to be no injury. Thus Stylonychia (including dividing forms), irradiated even with as large a dosage as 219,000 ergs/mm² at the midpoint of the exposure cell, showed no signs of destructive effects even after 48 hours; in fact a vigorous culture developed following irradiation. Paramecia irradiated with as high a dosage as 191,000 to 200,000 ergs/mm² divided actively following their addition to bacterized medium; and when placed under conditions favorable for conjugation[7] they conjugated comparably to controls 72 hours after irradiation. The ability to divide and conjugate entirely normally would indicate that the Paramecia were but slightly affected. Paramecia irradiated with a dosage of 206,000 ergs/mm² at 3,660A (intensity: 100 ergs/mm²/sec.) seemed entirely unaffected.

At 3,025A, about 20 per cent. of the light incident upon a Paramecium is absorbed, whereas at 3,130A only about 3 per cent. is absorbed.[6] One would expect a proportionally weaker action of the longer wave-length for a given incident radiation on the basis of the absorbed energy. But even when the incident dosage at 3,130A is increased 12-fold (200,000 ergs/mm²) over that necessary to kill at 3,025 (16,500 ergs/mm²) the Paramecia were apparently unaffected. The energy absorbed must be voided without obvious injury.

Possibly at higher intensities lethal effects might be manifested at 3,130A. Such experiments are planned with the use of another light source. However, the intensities reported by Weinstein are low compared to those employed in the present work. It therefore seems probable that the strong lethal effects reported by him were due to impure light at 3,130A, since the large fused quartz prism in his monochromator may have scattered the lethal shorter wave-lengths to a considerable degree.

That there should be so sharp a difference in lethal action between regions of the spectrum so close together as 3,025 and 3,130A is not surprising in view of the partition of these wave-lengths in the sunlight at the earth's surface. According to Fabry and Buisson[8] the energy at 3,022A on June 7, 1920, with the sun at the zenith, was 2,700, whereas the energy at 3,143 was 22,400 (arbitrary units). Therefore, even at this time of the day, when the intensity of light of the shorter wave-lengths is greatest, the energy content at 3,022 is less than one eighth that at 1,143A. Earlier and later in the day the fraction is much smaller. One would therefore expect organisms to be so adapted to that part of the sun's spectrum in which light is present in relatively high intensities as to absorb little and to be able to get rid of the small amount absorbed without injury. The wave-length 3,130A is beyond the limit of the strong absorption band of the protoplasm of bacteria,[9] Paramecium,[6] and human skin[10] as well as of proteins[11] and of nucleoprotein derivatives.[12] And one finds little action at 3,130A; this is true not only for lethal action, but also for erythema production.[13] The small amount of energy which is absorbed under experimental conditions is apparently voided without noticeable injury.

A. C. GIESE
P. A. LEIGHTON

STANFORD UNIVERSITY

[5] Giese and Taylor, *Arch. Prot.* In press.
[6] Giese and Leighton, *Jour. Gen. Physiol.* In press.
[7] Giese, *Physiol. Zool.* In press.
[8] Fabry and Buisson, "L'Absorption des Radiations dans la Haute Atmosphere," 1930.
[9] Gates, *Jour. Gen. Physiol.*, 14: 31, 1930.
[10] Bachem and Kunz, *Arch. Phys. Therapy, X-ray, Radium*, 10: 50, 1929.
[11] Henri, Henri and Wurmser, *Compt. Rend. Soc. Biol.*, 73: 319, 1912.
[12] Holiday, *Biochem. Jour.*, 24: 619, 1930.
[13] Luckiesh, Holiday and Taylor, *Jour. Op. Soc. Am.*, 20: 423, 1930.

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